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CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicag

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VOL. XX, No. 8 NOVEMBER, 1920 WHOLE No. 172

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE PASSIVE STATE: A REVIEW OF THE THEORIES.

BY J. H. REEDY,
University of Illinois, Urbana, Ill.

The fact that certain metals may become inactive, and behave towards chemical reagents as if they were nobler than would be expected from their place in the E. M. F. series, has been known for more than a century. But simple as this fact is, chemists have never been able to explain it in a manner that is wholly satisfactory, and the phenomenon still remains one of the unsolved problems of the science.

Passivity was discovered in the case of iron, and this metal still remains not only one of the most marked, but one of the most baffling examples of this phenomenon. John Kier in 1790 found that iron which had been dipped in fuming nitric acid had lost its normal chemical behavior, such as the displacement of hydrogen from dilute sulfuric acid, and copper from copper sulfate solution; in fact, it behaved as one of the noble metals. Schoenbein called this state of chemical inactivity "passivity." More recently the phenomenon has been found to exist in other metals, notably chromium and nickel.

The lists of metals assuming the passive form as given by various writers are not identical. All include iron, chromium and nickel—the metals which show the phenomenon in its most

marked form. Beyond these three elements, differences appear. Some consider cobalt to show passivity of the normal type, while others deny its genuineness. In addition to the metals just mentioned, those most frequently classed as passive are bismuth, molybdenum and tungsten. Some give larger lists, including elements like copper, lead and silver. In this extended sense, aluminium is said to be passive in nitric acid since there is no appreciable action. Some go even further and speak of pure zinc being passive when it does not dissolve in dilute sulfuric acid. An interesting case of this sort is gold, which has been reported by Coehn and Jacobsen.[1] When gold is made the anode in $AuCl_3$ solution, it dissolves at about the rate that would be expected from Faraday's law until an anode potential of about 1.2 volts[2] is reached. Above 1.4 volts, however, the metal becomes passive, and no action occurs until 1.73 volts is reached, when chlorine ions begin to be discharged.

These differences doubtless arise, not only from differences in the degree of passivity shown by various metals, but from different conceptions as to the nature of the phenomenon in the minds of the various writers. Some (e. g., Heathcote) assume that passivity is wholly electrochemical in nature, and consequently do not include in their lists metals whose passivity is chemical only. Very probably, if all could agree upon a definition of passivity, the conflict in opinions would be largely reduced. It might be said in this connection that most writers now appear to limit passivity to those cases where no visible protecting layer forms on the surface of the metal.

Passivity may be induced in two ways: (1) By the action of oxidizing agents, as HNO_3, H_2CrO_4, H_2O_2, etc.; and (2) by anodic polarization; that is, by making the metal the anode in an electrolytic cell containing alkalies, or solutions containing such anions as NO_3- and SO_4-. This inactive condition is not permanent, but disappears slowly on standing, and more rapidly upon subjecting it to heat, mechanical strains, action of non-oxidizing acids like HCl, cathodic polarization, contact with active metals, and so forth.

The Oxide Film Theory.—The earliest theory to explain passivity was the formation of a film of oxide, which acts as a protective layer, preventing further corrosion. This theory is usually accredited to Faraday, although he merely suggested it

[1]Z. anorg. Chem., *55*, 321 (1907).
[2]Referred to the normal hydrogen electrode as 0.0 volts.

as a possibility. The evidence in favor of it is forceful, even if not conclusive. It is well known that a layer of Fe_3O_4 passivates iron against rusting. In exactly the same way, a coating of Al_2O_3 may protect aluminium, and $PbSO_4$ protect lead. It seems perfectly reasonable that the mechanism for passivating other metals should be analogous. Another line of evidence that favors the oxide film theory is the fact that metals showing the passive state are not attacked by strong alkalies, presumably due to the formation of a film of oxide on their surface. For example, iron may be used as anodes in the electrolysis of caustic soda solutions.

There are, on the other hand, a number of serious objections to the oxide film theory. (1) In many cases there is no visible film of oxide; furthermore, experiments on the reflecting power of passivated metals[3] show that the film (if any) must be of probably less than molecular dimensions. (2) The known oxides do not meet the requirements of the hypothetical oxide in the way of resistance to chemical action. (3) The destruction of passivity by heat is unexplainable in terms of the oxide film. (4) Passivity is removed by contact with air, an oxidizing agent. (5) The single potential of a passive metal varies, and is not constant as would be the case with a metal-metallic oxide electrode. And (6) Hittorff's "experimentum crucis": Chromium, which dissolves in hydriodic acid with the formation of hydrogen and chromous iodide, becomes passive when it is made the anode in the same solution. It is hardly conceivable that an oxide of chromium could have been formed under such conditions.

For reasons such as the above, the oxide film theory is no longer generally accepted, however sufficient it may be in some specific cases. A few years ago a symposium was held in London under the auspices of the Faraday Society,[4] at which papers were read setting forth the views of various prominent men on this interesting phenomenon. It is quite noteworthy that of the seventeen papers and discussions, only one seemed to favor the oxide film theory. But that does not mean that there is any unanimity among chemists as to the physical basis of passivity. Some of the other theories are outlined below.

Gas Film Theories.—Another explanation of the phenomenon

[3]See Mueller and Konigsberger: Z. Elektroch., 13, 659 (1907).
[4]Trans. Farad. Soc., *9*, 203 (1914).

of passivity is the formation of films of oxygen or hydrogen, which envelop the surface of the metal and prevent chemical action.

Fredenhagen[5] and Flade[6] have suggested that the metals that show passivity react slowly with the oxygen formed by the decomposition of certain passivating anions when they are discharged. This insulating film in turn exercises a valve action upon the passage of the electric current, so that no corrosion takes place until a higher voltage is impressed, and then it is usually of a different character from what might be considered the normal action. This hypothesis explains very well why passivity is destroyed by heat, and why optical measurements have been unable to detect any change in the surface of the metal. It is open, on the other hand, to some serious objections, viz.: (1) Many passive metals are readily oxidizable, and a retardation in oxide formation is hardly to be expected; (2) it does not explain how iron is passivated in alkalies; and (3) Grave[7] has shown that iron can be passivated by heating in an atmosphere of nitrogen.

That the gas film causing passivity is hydrogen, and not oxygen, is a very interesting supposition, and one that has been developed in slightly differing forms by several writers. The general idea is that hydrogen is a catalyst for the corrosion of the metal, and lacking it, the metal becomes passive. To quote Schmidt's words[8]: "Just as water or other liquids do not boil, even when their vapor pressure is equal to that of the superincumbent pressure, unless a catalyst such as air is present, so the metals which can be passivated dissolve rapidly only in the presence of a catalyst. The most important of such catalysts is hydrogen."

According to Foerster's hydrogen activation hypothesis,[9] the presence of a layer of hydrogen on metals is the normal condition. In the case of the discharge of oxidizing anions, this hydrogen film is removed by oxidation, so that the corrosion action lags for lack of a catalyst. Sackur's hypothesis[10] differs

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[5] Z. phys. Chem., *43*, 1 (1903); ibid., *63*, (1908).
[6] Z. Elektroch., *18*, 335 (1912).
[7] Z. phys. Chem., 77, 513 (1911).
[8] Trans. Farad. Soc., *9*, 265 (1914).
[9] Abhand. der Bunsen. Gesell., No. 2 (1909).
[10] Z. Elektroch. *14*, 612 (1908).

from the others mainly on the point of how the hydrogen layer is formed. He represents it as formed by the reversible displacement of H_+–ions of the solution by the metal. That is, for a monovalent metal,

$$2 \text{ metal atoms} + 2H_+ \rightleftarrows 2 \text{ cations} + H_2.$$

This theory gives an ingenous explanation of certain facts. For example, certain metals become active when they are heated in an atmosphere of hydrogen, but passive when heated in nitrogen or a vacuum.

Grave[11] supposes that it is not the hydrogen molecule, but the hydrogen ion that causes activity. These ions are absorbed on the surface of the metal and act as the specific catalyst for the corrosion. Evidently, this gives a good explanation for the passivity of iron in alkaline solutions, by the assumption that these activating H^+-ions are removed by the OH^--ions of the solution, leaving the metal passive.

Some of the objections to the various forms of the gas film theory have been met by supposing that the gas does not exist as such, but in the form of an alloy or solid solution with the metal. For example Grube[12] and Reichinstein[13] have urged that passivity is due to the superficial formation of an oxygen alloy (or an oxide alloy) with the anode metal. Others have suggested a hydrogen alloy hypothesis.

Valency Theories.—It is a frequently recurring idea that valence is a property, not only of compounds, but of the uncombined elements themselves. Allotropism has been explained in this way. Starting with this concept, it is easy to imagine that the differences shown upon a metal passing from the active to the passive state are directly due to a change in valence. Finkelstein has assumed that the several modifications of a metal are present in every sample, their proportions depending on temperature, electrical potential and other factors. The chemical behavior of a metal would be governed by the relative concentrations of these allotropic forms. Such a theory, however, would call for a gradual transition from one form to another, and is unable to explain the abrupt changes reported in several metals. Nor does it throw any light upon the conspicuous part played by anions in inducing and destroying passivity.

[11] Z. phys. Chem., 77, 513 (1911).
[12] Z. Elektroch. 18, 189 (1912).
[13] Trans. Farad. Soc., 9, 228 (1914).

The most recent of the valency theories is probably to be found in A. W. Stewart's theory of isobaric iron.[14] He considers active iron as bivalent, calling it ferrosum, and finds it to resemble magnesium in its chemical behavior. Partially passivated iron is trivalent (ferricum), and resembles aluminium. Passive iron he imagines as nonvalent, and calls it ferron, after the analogy of argon. No explanation is given of the specific influence of oxidizing anions in effecting the changes of ferrosum to ferricum, and ferricum to ferron.

Drude's electron theory of metals has been extended by R. S. Dean[15] to explain passivity. According to this hypothesis, passivity is due to the removal of the surface electrons by oxidizing agents or anodic polarization, leaving the surface positively charged to a degree corresponding to the higher valences of the metal in question, and resulting in its ennobling. How the resulting deficiency of electrons on the surface of the metals is maintained is explained by the high permeability of the passive metals for electrons, with the result that the electrons on the surface of the metal escape readily into the electrolyte leaving it with a positive charge. Dean insists on two aspects of the passivity problem that are infrequently mentioned, viz.: (1) Passivity is characteristic of paramagnetic bodies only, and (2) it is harder to induce when the metal is under the influence of a magnetic field.

Anion Discharge Theories.—Chemists do not agree as to the mechanism of the reaction when an anode is corroded. One group likes to think of the metal as ionizing directly, and the anions entering into the reaction in a secondary way only. Another group prefers to think of the anions being discharged directly upon the anode, and the discharged ions, or their fragments, attacking the anode material. This latter view is the basis of what has been called the anionic discharge theory of passivity, and has been proposed in varying forms by several writers. In the event the products of the reaction between the metal and the discharged ion are not removed from the anode surface by solution or diffusion, a layer accumulates forming a barrier between metal and solution, breaking the current. This layer does not need to be of more than molecular thickness to effect passivity; furthermore, this form of passivity might be removed by the presence in the solution of some ion or group

[14]Stewart: "Recent Advances in Physical and Inorganic Chemistry" (1919), p. 246.
[15]Am. J. Sci., *47*, 123 (1919).

that will combine with this insulating layer. According to the opinion of some when anions like NO_3^- and SO_4^{--} are discharged the ion reacts with water or else decomposes, with the formation of oxygen in either case. This oxygen forms a film on the surface of the metal, and this gap prevents further discharge of anions. Considered in this light, the anion discharge theory resolves itself into the Fredenhagen oxygen film theory. On the other hand, Sackur has called the anionic discharge hypothesis into requisition in his hydrogen film theory by assuming that any ion which, upon discharge, will remove the insulating hydrogen layer will prevent passivity. Such ions as Cl^- accomplish this readily, while others like NO_3^- do not. In order to explain why the latter ion is so uneffective in removing the hydrogen layer (which is a very surprising assumption, to say the least) some form of retarded reaction velocity theory must be invoked. So it often happens that some of the theories advanced to explain passivity are not simple concepts, but rather combinations of several hypotheses.

Reaction Velocity Theory.—It seems that at the present time chemists, for the most part, favor a retarded reaction theory of passivity. That is, some step in the solution of the metal may have its velocity reduced almost to the vanishing point, with the result that the metal remains practically undissolved. However, they differ among themselves as to just which step in the process is the one retarded.

Le Blanc[16] has suggested that certain metals may have a low ionization velocity; or—what amounts to the same thing—the ions may have low speed of hydration. The successive steps in the anodic solution of a metal then are:

$$(1)\ \text{Metal}^+ \oplus \rightleftarrows \text{Cation}^+;$$

$$(2)\ \text{Cation} + H_2O \rightleftarrows \text{Cation-hydrate}^+.$$

A metal is passive, owing to a retardation of one of these reactions. As a result, the ionization potential is easily exceeded, and at a higher potential discharge of the anions begins with little or no action on the metal. In this way, insoluble products (as oxygen, oxides, etc.) may be formed by the discharged anion, but in this case the formation of the insoluble layer is a result rather than a cause of passivity.

This conception of a retarded reaction appears in a number of the theories mentioned above. It is implied in the hydrogen activation theory of Forester, where the action is supposed to

[16] Loc. cit.

be catalyzed by hydrogen, and to lag when it is absent. Similarly in the anionic discharge theories, the oxygen layer is due to a retardation of the oxide formation.

Catalytic Theories.—An extension of the reaction velocity theory is that the anode reaction is retarded from lack of the proper catalyst. The usual assumption is, the pure metal is passive by reason of a slow step in the corrosion process, but this slow step may be accelerated by aid of a specific catalyst. The hydrogen activation theory, as developed by Foerster[17], Schmidt[18] and others is the highest type of this hypothesis. The hydrogen is supposed by Foerster to be molecular, while Schmidt and Grave believe that the activating agent is the hydrogen ion. Like Le Blanc, Foerster thinks that the formation of the oxide film is a result, rather than a cause of passivity. Any process that would remove hydrogen, as polarization in the presence of OH^- or other oxidizing anions, would leave the metal passive.

In concluding, it should be said that probably a final and truly comprehensive explanation of passivity has not yet been brought forward. While the oxide film theory is in general disfavor at this time, still there are certain cases (e. g., lead) where solid protective films are known, and for these the old theory seems sufficient and correct. With most other metals, some other explanation seems necessary. As pointed out above, the reaction velocity concept finds most general acceptance at this time, although it is sometimes berated by its opponents because its advocates cannot agree among themselves as to just where the retardation occurs. Very probably a general theory of the mechanism of passivity will never be realized.

[17] Loc. cit.
[18] Z. phys. Chem. 77, 513 (1911).

NO HIGH PLACES IN FLORIDA.

The highest point in Florida whose altitude has been determined is Iron Mountain, in Polk County, which stands 325 feet above sea level, according to the United States Geological Survey, Department of the Interior. The average elevation of the State as computed by the Geological Survey is about 100 feet.

GUAM.

Guam, our little Pacific Island possession, is a mere speck in the "South Sea," as Balboa called the Pacific Ocean, but it is by no means flat. Jumulong Mangloc, the highest point in the island, stands 1,274 feet above the sea, according to a chart published by the United States Geological Survey, Department of the Interior.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge,

University of Oklahoma, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be non-technical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to Homer L. Dodge, Department of Physics, University of Oklahoma, Norman, Oklahoma.

THE PRODUCTION OF DAMPED RADIO-WAVES.

BY WILLIAM SCHRIEVER,

University of Oklahoma, Norman, Okla.

This article is the first of a series of articles dealing with the application of the principles of physics to wireless telegraphy and telephony. The study of complicated circuits such as are often used in practice has been purposely omitted, since the theory of operation which applies to them is more easily explained by the consideration of the simplest apparatus. Descriptions of some pieces of apparatus actually used in practice have been added, since it was thought that this would be of interest to the practical experimenter.

Wireless signals are carried through space by "radio waves" which are produced by "oscillating circuits." The simplest circuit in which electrical oscillations may occur consists of a condenser and an inductance coil connected in series. Figure 1 shows such a circuit, C being the condenser and L the inductance coil. Of course, a coil having no resistance cannot be constructed, so any circuit used in practical experiments will also have this characteristic.

A condenser, then, is one of the essential elements of an oscillating circuit. In general, a condenser may be considered to consist of two electrical conductors (sheets of foil, wires, metal plates, etc.) electrically insulated from each other by a dielectric (air, glass, paper, mica, etc.). Thus the aerial or antenna of a wireless station is a condenser, the wires of the antenna being one conductor, the earth the second conductor, and the air the dielectric. The insulators which insulate the antenna from the supports also form a very small, though important, part of the dielectric.

If a condenser of sufficient capacity and an electric light bulb be connected in series between ordinary sixty cycle one hundred and ten volt alternating current mains, as is shown in Figure 2,

the lamp will glow, showing that a current is flowing through it. But if one hundred and ten volt direct current is used instead of the alternating current, the lamp does not glow, indicating that no current is flowing. However, if a suitable ammeter be substituted in the latter case, a deflection will be observed on first closing the circuit after which the pointer will return to its original position. This shows that a current flowed for a brief period and then ceased. If the connections at A and B be broken and the free lead from the condenser be touched to the free lead of the ammeter, a deflection of the pointer in the opposite direction will be observed, showing that electrical energy was stored up in the condenser.

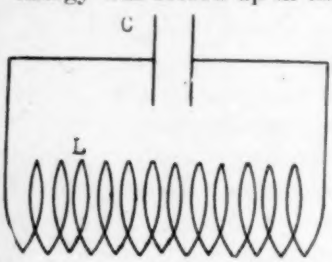


FIGURE 1

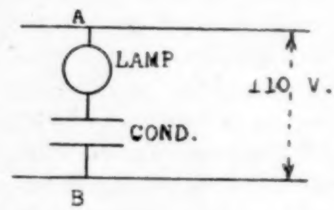


FIGURE 2.

Let us again consider the phenomenon of the glowing electric light bulb mentioned in the preceding paragraph. Suppose that when the circuit is first closed the alternating current main A is at the beginning of a cycle of increasing positive potential. As the potential of A increases for one two-hundred and fortieth of a second a current flows from A through the lamp into the the lower plate of C into the main B. The condenser is now said to be charged. During the next one two-hundred and fortieth of a second the potential of A decreases to zero and during this time a current from the top plate of the condenser flows through the lamp to A and an equal current flows from B into the lower plate. The condenser is now discharged. During the third one two-hundred and fortieth of a second the main B becomes positive and the charge flows into the lower plate of the condenser and, as before, an equal charge flows out of the top plate through the lamp into the main A. And at the end of the fourth one two-hundred and fortieth of a second the condenser is again discharged. Thus, when using sixty cycle alternating current through the circuit in question, the condenser is charged and discharged one hundred and twenty times per second and the pulses of current through the

lamp change direction an equal number of times. Since the heating effect of a current is independent of its direction of flow, the heat produced by all the little pulses is the same as that caused by an equivalent unidirectional current. The points to be observed here are, first, that it is possible to store electrical energy in a condenser, and second, that it is possible to transmit electrical energy through a condenser.

Next, let us consider the action of an inductance. If one end of an insulated copper wire, several hundred yards long, be connected to one terminal of a battery of several dry cells and the other end be scratched across the other terminal of the battery, only a very feeble spark will be observed. However, if this same length of wire is wound into a coil on a wooden spool, the sparking is much more vigorous, and if a bundle of soft iron wires is used in place of the wooden spool the sparking effect is increased still more. Evidently the available energy at the breaking of the circuit in the last two cases must be greater than that obtained when a single loop of wire is used. To study this action more in detail, connect a suitable ammeter, A, a coil of insulated wire, L, a double-contact key, K, and a cell, V, in series as is shown in Figure 3. Also connect a resistance R around the cell to the key-contact "Y." When the

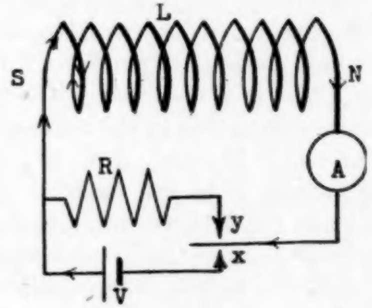


FIGURE 3.

key makes contact at "x," the current flows as is indicated by the arrows and the pointer of the ammeter deflects, say, to the right. If the inductance of L be sufficiently large it will take some little time for the current through it to reach the final steady value, which is indicated by a constant deflection of the ammeter. If the key is suddenly changed from the "x" to the "y" contact, the current, instead of instantly becoming zero, continues to flow in the same direction as it did while the cell

was in the circuit, though decreasing rapidly in strength until a value zero is reached. It is evident, from the continued deflection of the ammeter after the cell is cut out of the circuit, that energy is somehow stored up in the circuit. The sparking at the break of a circuit containing a coil, as mentioned above, shows that this energy is stored in some manner by the coil.

The slow building up of the current in the circuit and the continuance of the flow mentioned in connection with Figure 3 may be explained in the following manner. When the current flows through the coil a magnetic field is produced in and around it and the coil has the properties of a magnet (poles marked in Figure 3). Such a magnetic field cannot be built up instantaneously. During the time that it is being built up, the number of "magnetic lines of force" associated with the coil is changing. It will be remembered that, when the number of lines of force through a coil is changing, an electromotive force is induced in the coil, and that this electromotive force is in such a direction that the magnetic field of the resulting current opposes the inducing field (Lenz's Law). Therefore, while the magnetic field is building up the "back" or "counter" electromotive force induced in the coil opposes the electromotive force of the cell; this keeps the current from attaining its full strength at once. When the cell in Figure 3 is suddenly replaced by the resistance, the magnetic field associated with the inductance coil and the current through it have nothing to maintain them, so they tend to reduce to zero. But any reduction in the strength of the magnetic field means a reduction in the number of lines of force associated with the coil. The coil, then, is again cutting lines of force and this cutting is in the opposite direction to that which took place when the field was building up. The induced electromotive force is therefore such as to cause a current to flow in the same direction as the original current. The points to be observed in regard to the action of an inductance coil are, first, that energy can be stored in a magnetic field, and second, that such a coil tends to prevent the current through it from changing in amount.

The operation of the oscillating circuit of Figure 1 depends on the energy-storing properties of the condenser and inductance coil. First assume the coil to have no resistance and the condenser C to be charged and then connect the inductance coil L to it as shown. The condenser immediately starts to discharge through the coil and, in so doing, builds up a magnetic

field associated with the coil. When the condenser is completely discharged all of its electrical energy has been used in building up the magnetic field of the coil. As was explained before, the field breaks down and consequently induces a current flowing in the same direction as the one which originally produced the field. The amount of electrical energy produced is just the same as the amount which originally caused the magnetic field, namely, the amount of energy which was in the condenser (since we assumed no energy losses such as would occur in a circuit having resistance). Therefore, the condenser is now charged so that it has the same energy that it had originally, the only difference being that it is charged in the opposite direction. Thus the circuit again contains a charged condenser in series with an inductance coil. The condenser discharges through the coil as before, builds up a magnetic field which again breaks down and charges the condenser so that it is in the same condition that it was originally. Two such surges of current taking place in opposite directions, immediately following one another, constitute one complete electrical oscillation. In the ideal circuit the surges of current back and forth would go on forever, much the same as a weight oscillating up and down on the end of a coil-spring would continue to oscillate forever if there were no friction of any kind.

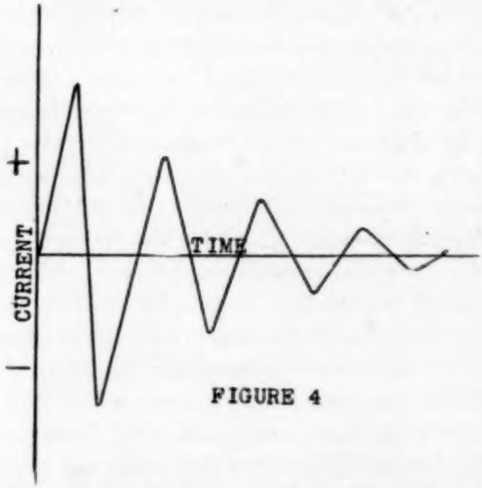


FIGURE 4

In practice, of course, there are heat losses in the wire of the inductance coil. Therefore the maximum current flowing during a given cycle is less than the maximum flowing during the preceding cycle as is shown in Figure 4. In this diagram the

instantaneous values of the current are plotted as ordinates with the corresponding times as abscissas. Each loop, either above or below the time axis, represents a half-cycle and it is to be observed that the height of a loop (maximum value of current) decreases with time. This decrease in current goes on until finally all the original energy of the condenser is dissipated as heat; then the oscillations cease. Oscillations which decrease in strength as time goes on are said to be "damped" and the whole group of oscillations shown in Figure 4 is called a "train of damped oscillations." The frequency of the oscillations depends only on the capacity of the condenser and on the inductance of the coil when the resistance of the circuit is small. If L is the inductance in henrys, C the capacity in farads, then the frequency in cycles per second is $f = 1/2\pi\sqrt{LC}$. The frequencies used in "radio" usually range between 100,000 and 1,000,000 cycles per second. The time required for a whole train of damped oscillations is of the order of one one-thousandth of a second, and the number of complete oscillations in a single train is therefore from 100 to 1,000.

Each complete train of oscillations produces a single pulse of current through the phones of the receiving set (this will be explained in a later paper). Consequently the pitch of the note heard in the phones will be the frequency at which the trains of oscillations are produced. If this frequency is that for which the human ear is most sensitive, less energy is necessary at this frequency than at other frequencies when the same audibility of signals is produced. The human ear is very sensitive to sounds whose pitch is about 1,000 cycles per second. Hence this is the rate at which trains of oscillations should be produced in order that the maximum range of transmission for a given circuit may be obtained. In order to accomplish this it is necessary to give the condenser 1,000 initial charges per second, and to allow oscillations to occur for each of these charges. One of the simplest circuits for producing 1,000 trains of oscillations per second is shown schematically in Figure 5. G is an alternating current generator whose frequency is 500 cycles per second. The current from this generator flows through the primary of the "step-up" iron-core transformer when the key is closed. The secondary or "high-side" of the transformer is connected to the terminals of the condenser, C, which is in series with an inductance coil, L, and a spark-gap. C, L and the spark-gap form the circuit in which the oscillations are to take place.

When a 500 cycle generator furnishes the power, 1,000 trains of oscillations will be produced each second in the oscillating circuit, as may be seen from the following considerations. The current through the primary attains a maximum value, either positive or negative, once during each half-cycle or 1,000 time per second. For each maximum value of the current in the primary a maximum electromotive force is induced in the secondary of the transformer and this electromotive force is

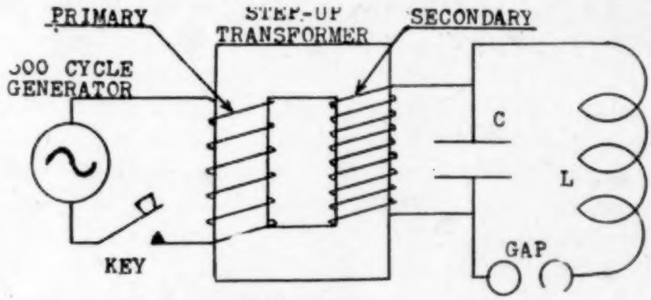


FIGURE 5

applied to the condenser which, therefore, becomes charged. At the time that this induced electromotive force is a maximum, the spark-gap "breaks down" (spark passes across the gap). Due to the great ionization of the air in the gap it becomes a relatively good conductor while the spark is passing. Therefore the condenser, which was charged before the gap broke down, discharges and recharges through the gap and the coil thus producing a complete train of oscillations in the oscillating circuit. For each spark, then, a whole train of oscillations is produced. Since a spark occurs at each maximum induced electromotive force in the secondary, 1,000 sparks will pass and, therefore 1,000 trains of oscillations will be formed per second.

The spark-gap is necessary. If there were no gap, and instead the circuit were completed by some electrical conductor, the current in the secondary of the transformer would pass around through the coil. Under these conditions the condenser would not be charged and oscillations would not occur. The spark-gap acts as a sort of automatic switch which opens so that the condenser will be charged and closes (spark passes) so that the circuit may oscillate. The condenser does not discharge through the secondary of the transformer since the effective resistance of the secondary is large compared to that of the gap and coil in the oscillating circuit.

As long as the key in the primary circuit is closed, sparks

and therefore trains of oscillations will be formed at the rate of 1,000 per second. A radio operator, when sending at the rate of about twenty words per minute, holds the key down one

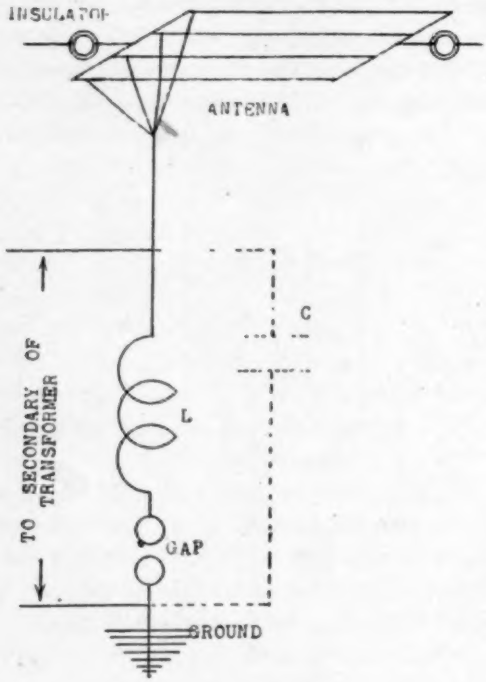


FIGURE 6

twenty-fifth of a second when he makes a "dot" and three twenty-fifths of a second when he sends out a "dash." The dot, therefore, is represented by forty trains of oscillations and the dash by one hundred twenty trains.

We have now arrived at a method for the production of damped electrical oscillations but the possibility of radiating any of the energy in the form of waves in the ether, namely radio waves, has not been considered. An ordinary experimental circuit set up in the laboratory radiates only a small amount of the energy in this way; the remainder is dissipated as heat. An oscillator which radiates a relatively large fraction of the energy is said to have a high radiation resistance. The usual method for increasing the amount of energy radiated by an oscillator is to use an aerial and the ground as condenser plates and the air as the dielectric as is shown in Figure 6. The dotted line condenser and wires simply show how the antenna and ground act as a condenser in series with the inductance coil, L, and the spark-gap.

The energy of a charged condenser is stored by what may be termed an electric strain in the dielectric between the plates. This strain is in the ether which permeates all space. In the case of the condenser formed by the antenna and the ground, Figure 6, the strain occurs in the dielectric, i. e., in the ether permeating the air, between the antenna and the ground. This strain is propagated through the ether in all directions from the antenna with the speed of light (186,000 miles per second). If the antenna is first at a positive and then at a negative potential, with respect to the earth, as it is in succeeding half-cycles in a train of oscillations, the ether is strained first in one direction and then in the other, all strains traveling out from the antenna with the same speed. If under these conditions the strains, due to the antenna's becoming positive (or negative), occur at the rate of a million per second, then similar positive strains will follow each other about 328 yards apart. This ether wave is said to have a wave-length of 328 yards or 300 meters. Thus each train of oscillations gives rise to a train of ether waves traveling out from the antenna into space in all directions. An antenna usually radiates more energy in some one direction than in any other direction; it is said to have a directional effect. Thus the inverted L antenna shown in Figure 6 radiates more energy toward the left in the figure than in any other direction.

A train of ether waves produced by a train of electrical oscillations may be likened to a train of sound waves emitted by a tuning-fork which has been struck with a rubber hammer. The sound waves coming from the fork are damped since their intensity decreases with time just as the intensity of the electrical oscillations, and therefore of the ether-waves, decreases with time. The pitch of the sound waves of a train of waves depends on the dimensions of the fork and on the material of which it is made; the frequency of the electrical oscillations is determined by the inductance and capacity of the oscillating circuit. The number of trains of sound waves produced per second will be the same as the frequency with which the fork is struck; in the case of the electrical oscillator the frequency of the trains is the same as the number of sparks per second. The length of the sound-wave in air depends on the pitch of the fork; the length of the electromagnetic wave in the ether is determined by the frequency of the oscillating circuit. In each case the wave-length is $l = V/f$, where V is the velocity of

propagation of a wave in the medium (air or ether) and f is the frequency of the oscillator (tuning-fork or oscillating circuit).

Amateurs usually do not have 500 cycle alternating current available but obtain the power for their transformers from the ordinary sixty cycle 110 volt alternating current house lighting mains. Since there is only one spark per half cycle, an oscillator furnished with power from a transformer supplied with this current will produce 120 trains of waves per second. This gives a very low pitch note (second B below middle-C on a piano) compared to a pitch of 1,000 cycles (second B above middle-C) for which the ear is very sensitive. In order to generate more sparks per second a rotary spark-gap is employed in place of the plain gap already mentioned. A rotary gap usually consists of a wheel mounted in front of two stationary knobs or points. The wheel has about ten projecting knobs or points, on the rim. which are so spaced that, as the wheel rotates, knobs on opposite sides of it are simultaneously in front of the stationary knobs The wheel is driven at the desired speed by means of a motor on the shaft of which it is mounted. In this case the spark has to pass across two short gaps, one from each stationary knob to the wheel. These gaps must be short since it is desired to have them break down when the electromotive force induced in the secondary is not at its maximum value. In fact it is possible to have eight sparks for each half-cycle of the primary current; in this case the number of sparks and therefore the note heard by the receiver will have a frequency of 960 cycles per second. The induced electromotive force varies during each half-cycle and consequently the tone heard at the receiver is not musical but it is of high pitch; it therefore has greater audibility than the 120 cycle note.

An induction coil equipped with a vibrator is a convenient source of high voltage for an oscillator if the amount of power desired is not large (less than one-fourth kilowatt). If the spark-gap is not too small, a spark will occur only at the break of the vibrator. Hence the frequency of the sparks will be the same as the frequency of the vibrator and this is usually less than 100 vibrations per second. Induction coils are rarely used in commercial radio sets but are very often employed by amateurs.

The plain spark-gap first described cannot be used in an oscillator of large power output for it becomes heated and serious arcing takes place. Moreover a spark once started lasts so long that this gap cannot be used with a 500 cycle generator set;

the spark is said to be not sufficiently quenched. The rotary gap overcomes this difficulty and it also remains cool and does not arc seriously. It is, however, very noisy and therefore disagreeable to use. The quenched gap overcomes all of these difficulties. The standard form of quenched gap consists of a number of flat, copper or silver discs of large surface, say about three inches in diameter at the sparking surface, with their faces separated by about 0.08 inch (thickness of three sheets of writing paper). To provide the necessary total length of gap for use with high voltages, a number of these short gaps are put in series so that the spark must jump them all. The disks are kept apart by rings of mica or of paper. This form of gap has had such a large surface for heat radiation that it keeps cool and thus does not arc. The ionized gas in the spark is quickly cooled by the large disks and the spark is quenched almost immediately after the gap has broken down; this allows the much-desired high-frequency generator to be used as the source of power.

The inverted-L antenna shown in figure 6 is a very common type of aerial. When the connection to it is made midway between the insulators instead of at one end this type is called a "T" antenna; it is also in common use. Both types are used on ships as well as on land. At some radio stations two inverted-L antennas are supported on three masts in such a way that the two sets of horizontal wires form a "V"; the connection is made at the ends supported by the same mast. Such an aerial is known as a "V" antenna. A vertical wire is the best radiator of electromagnetic energy but it is hardly possible to get one sufficiently long so that it can be used for long wave-lengths. An approximation to an antenna of this type is used on airplanes where a wire about 300 feet in length is trailed behind. The stay-wires and all metal parts of the airplane are electrically connected and take the place of the earth; they are called the counterpoise. A trailing-wire antenna has a very decided directional effect, most of the energy being radiated in the direction in which the airplane is flying. The umbrella type of antenna consists of a number of wires fastened at one end to the top of a tall mast by means of insulators and at the other end to insulators which are attached to anchors; these wires also serve as the guy-wires for the mast and so extend in all directions from the mast as center. The electrical connection is made at the top ends of the insulated sections of the guy-wires. This sort of an antenna radiates energy equally in all directions; it is used at many of the powerful radio stations.

INTRODUCTORY COURSES IN BOTANY. V.

By Bradley M. Davis,
University of Michigan, Ann Arbor, Mich.

(Continued from April, 1920.)

OUTLINE No. 17.

A year's high school course, five to seven hours a week.

First half-year.

1. Study of a complete seed plant, including flower and fruit, for a comprehension of the plant as a unit composed of cooperating parts.
2. Leaf structure and leaf types. Uses of leaves determined by experiment. Edible leaves.
3. Flowers. Study of types from simple to complex. Pollination and fertilization.
4. Study of several autumn blooming plants for family characteristics.
5. Structure of monocotyl and dicotyl stems. Distribution of foods manufactured in the leaves. Economic uses of stems.
6. Roots. Garden plants to illustrate root form and food storage.
7. Fruits. Collection from the field and market to illustrate types of fruits and methods of seed dispersal.
8. Weeds. Kinds that seed in the autumn.
9. Bulbs and bulb planting.
10. Trees and forestry.
11. Pines. Acquaintance with several genera of conifers.

Second half-year.

12. Brief study of pteridophytes.
13. Brief study of bryophytes.
14. Brief study of thallophytes.
15. Bacteria.
16. Plant diseases.
17. Seeds and seedlings. Selection and improvement of soils.
18. Spring wild flowers. Representatives of families.
19. Study of native and cultivated shrubs to recognize kinds.
20. Practical garden work. Recognition of weeds

The purpose of the course is to develop a wide-awake interest in growing plants and a general understanding of their vital and economic values. As much work should be carried on out of doors as weather and time will permit.

OUTLINE No. 18.

A year's high school course, five times a week.

1. General study of some familiar plant to understand its parts and their functions. This introductory study is accompanied by field trips on which common plants are noted and various material collected for winter study.
2. Bacteria. Structure, physiology, and relation to disease.
3. Yeast, Structure and relation to fermentation.
4. Algae. Structure of Pleurococcus and Spirogyra. Food manufacture. Development of multicellular plants. Sex.
5. Fungi. Structure and life habits of bread mold. Life history of wheat rust. Mushroom. Saprophytism, parasitism. Economic importance.
6. Lichens. Structure. Symbiosis. Field trip.
7. Bryophytes. General structure of Marchantia. Structure and life history of a moss. Alternation of generations.
8. Fern. Life history with a study of the vegetative structure of the sporophyte. A comparison with the life history of the moss.
9. Pine. Study of vegetative structure and cones. Development of the gametophytes and seed. Field trips to distinguish different kind of conifers. Economic importance.
10. Angiosperms. A comparison with gymnosperms based on studies of the bean and corn. Then follows (11 to 15) a somewhat detailed study of angiosperm structure.

11. Roots. Forms and cell structure. Relation to the soil. Functions. Food storage and economic value. Experiments on osmosis and conditions necessary for growth.

12. Stems. Kinds and modification of forms. Cell structure and methods of growth in monocots and dicots. An examination of woods, their economic importance. Grafting and budding.

13. Leaves. Various leaf forms. Cell structure in relation to physiology. Food manufacture, transpiration, respiration. A study of raw materials, conditions and products of photosynthesis. Tests for food products. Food storage and economic importance. Experiments and field trips.

14. Flowers. Several types studied for structure and functions of parts. Pollination.

15. Fruits and seeds. Types and structural adaptations. Dissemination. Foods, determined by tests. Germination of seeds with a study of necessary conditions.

16. Useful plants and their products. Cereals, sugar, oils, fibers, drugs, etc.

17. Weeds. Common forms. Dissemination. Damage. Control.

18. Forestry. Methods and importance of timber conservation.

19. Plant breeding. General principles and methods. Seed selection.

20. Plant diseases. Disease producing fungi. Important diseases and their treatment.

The course traces the development of plants from the simplest to the most complex, but the types are largely chosen with reference to topics, which are assembled about them. In the studies on stems, roots, leaves, etc., where physiology is introduced the teacher performs the experiments for the class. The field trips are regarded as valuable since the pupils thus see plants in their natural environment and collect their own material. Many of the topics studied are important in that they connect the scientific with the practical.

OUTLINE No. 19.

A year's college course, six hours a week.

1. Protoplasm and the organization of the cell. Physical structure and properties of living protoplasm as seen in such plants as Vallisneria, Elodea, stamen hairs of Tradescantia, Characeae, molds, etc. *Demonstrations*: Structural elements in stained cells of young and old tissues.

2. Algae. Border-line organisms (living). Unicellular and multicellular algae; structural characters and life histories of one or more types. Fertilization phenomena as in Fucus, which can be handled by the students themselves. *Optional studies*: Collections of algae common in aquaria, reservoirs, ponds, etc., and their classification in an elementary way. *Experiments;* Gas release in algae of the filamentous type. Tests for starch. Parallel studies on photosynthesis using larger aquatics and land plants. Respiration.

3. Fungi. (1) Molds. Water mold, fruit and bread molds; structure, nutrition, zygospore development demonstrated by cultural methods. (2) Yeast. Culture and morphological study, fermentation experiments. (3) Bacteria. Studies in hanging drop of non-pathogems, simple experiments in cultures and soil suspensions. (4) Fungi of the ascus type, rust, mushroom; general studies and demonstrations. General consideration of parasitism, saprophytism, symbiosis.

4. Liverwort and moss. Morphological features, life histories, nutrition. Sphagnum, its morphology, distribution, economic importance.

5. Fern. Life history. Display of fern allies and fossil forms.

6. Flower. Morphology. Pollination, fertilization, reduction divisions. Development of embryo. *Demonstrations;* Various types of flowers, reproductive structures in the gymnosperms, ovule development and fruit formation, germination of pollen. *Optional;* Observation of plant breeder's methods and general consideration of the principles of genetics.

7. Seeds. External and internal morphology of endospermic and non-endospermic types. Tests for storage products: starch, fat, oil, protein. Germination studies, interpretation of parts of seedling in terms of embryo. Tests for digestive products in germinating seeds and seedlings. Extraction of enzymes from leaves and seeds (barley). *Demonstrations;* Fruits and seeds, interpretation of parts, adaptations for dissemination. *Optional;* Garden plot, seed selection, testing, disinfection, planting. Soil studies.

8. Structure of young plant (anatomy and histology). Dissection of macerated tissues to determine various structural units. Freehand sections from seedlings of monocots and dicots of roots, stems and leaves, the interpretation of their tissues and functions. *Experiments;* Diffusion, osmosis, plasmolysis, transpiration, absorption. *Demonstrations;* Wood sections showing differentiation of tissues in their mature form. Forest products. Textile fibers. Comparison of normal and diseased tissues of plants of local and regional importance. *Optional;* A study of the trees with keys adapted to the region. Tree planting, grafting. Ecological studies, represented by cross sections of a woodland area, open country, shore line, pond, lake, etc. Contact with the literature on the subject of forestry and problems related to it obtainable from state and federal bureaus.

9. Bud and twig studies. Content of the winter bud. Tests for storage areas. Observations on the unfolding of buds, growth of twigs, and the addition of new leaves and buds.

10. Key studies. Emphasis on the dominant plant families of the region. General principles of classification. Principles of evolution. Plant distribution. *Demonstrations;* Representatives of the great groups of plants with emphasis on those of economic importance.

The course is designed to give training in the fundamentals of structure essential to the interpretation of function in the living plant. The studies are assembled about the great groups to facilitate the orientation of the student in the plant world and to those portions of it that relate themselves conspicuously to human activities.

Outline No. 20.

A half year's college course required in a premedical curriculum, one lecture, two quizzes, and six hours laboratory work each week.

The lectures mostly treat of principles of plant biology with the subject of organic evolution an outstanding feature. Morphology, life histories, physiology and a simple classification are developed chiefly in the quiz periods, the discussions being based on the laboratory work and text book study. Physiological experiments are introduced as demonstrations.

1. Plant cell. Elodea, for structure and protoplasmic movement plasmolysis, osmosis. Euglena or Chlamydomonas for motile protoplasts.

2. The leaf. A short demonstration and discussion of leaf form. Sections of geranium leaf for chlorenchyma, epidermis and hairs. Epidermis of Boston fern (stripped) for stomata. Stained sections of Andromeda leaf for details of cell organization (slides).

3. Chloroplasts and formation of starch. Fresh sections of stem of Pellionia, later stained with iodine.

4. The stem. Brief discussion and demonstration of stem morphologyr Transverse and lengthwise sections of corn stem (slides). Cross section. of Ricinus stem, two stages covering formation of cambium cylindes. Cross sections of one and two year old stems of Aristolochia, and four year old stem of linden (slides). Study of quartered oak blocks with brief examination of slides.

5. The root. Seedlings of radish for general morphology of young plant and for root regions and root hairs. Root tip of onion (slides). Cross sections of corn root (slides).

6. Mitosis and cell division in root tip of onion.

7. Foods and food storage. Potato starch. Whole wheat flour (starch and protein). Starch from endosperm of corn seedling in process of conversion, compared with starch in ungerminated kernel. Sections of Ricinus endosperm (1) test for starch with iodine, (2) stain with Sudan III in alcohol, (3) sections left a few minutes in absolute alcohol to remove fat (oil) then stained with iodine or eosin for structure of aleurone grain. Test sections of cotyledon of bean or pea for character and relative amounts of food.

8. Bacteria. Forms from cultures decaying peas, infusions, etc. Spore formation from cultures of Bacillus subtilis. Observations on flasks of milk, (1) left open at room temperature and in ice box, (2) plugged with cotton, pasturized by heating to 65° C one half hour, kept at room temperature, and in ice box (3) plugged, heated to 98° C one half hour, kept at room temperature, (4) plugged, heated to 120° C fifteen minutes, kept at room temperature. Root tubercles on clover.

9. Yeast. Structure from cultures in very dilute molasses. Experiments on fermentation.

10. Simple algae such as Gloeocapsa, Pleurococcus, etc.

11. Spirogyra. Detailed study to cell structure, plasmolysis. Conjugation.

12. Vaucheria. Structure and reproduction.

13. Fucus. Structure. Fertilization on the slide. Substitute for Vaucheria if material is available

14. Rhizopus. Structure and life habits. Zygospore formation from cultures or from slides.

15. Microsphaera. Life habits, ascocarps.

16. Corn smut or loose smut of oats (brief study).

17. Wheat rust. Life history with examination of uredospores, teleutospores, and aecidia on barberry (slides).

18. Mushroom. Morphology and life habits. Demonstration of bracket fungi, puff balls, etc.

19. Moss. Thorough study of life history to establish alternation of generations. Discussion of chromosome reduction.

20. Marchantia. Brief study, emphasizing the small sporophyte.

21. Sphagnum. Brief study and discussion of life habits.

22. Fern. General morphology of sporophyte, structure of sporangium and development of spores (slides). Detailed study of prothallus, motile sperms, fertilization, young sporophytes. Life history thoroughly worked out

23. Selaginella. General morphology (briefly). Comes in detail. Life history explained.

24. Equisetum and Lycopodium. Brief study or demonstration.

25. Pine. General morphology. Staminate and carpellate cones. Slides of gametophytes about thirteen months after pollination. Pine seeds, demonstration of seedlings.

26. Flower. Structure of one or more types.

27. Anther and pollen development. Slides of lily anthers with several stages.

28. Ovary, ovules and embryo sac. Slides of lily ovaries.

29. Embryo and endosperm. Slides of lily.

30. Seeds and seedlings. Morphology and germination, bean, pea, corn.

31. Fruits. Demonstration and discussion.

The endeavor is made to put students promptly at work on concrete matter and make them by quiz and discussion do some reading and thinking. The first part of the course deals with the work of the seed plant, developing fundamental principles of plant physiology based on a study of structure. This is followed by a series of type studies with emphasis on the work and life habits of the fungi, and developing for the green plants the idea of a sequence or evolution of types. Life histories are worked out carefully from the bryophytes on, and there is thorough drill on the essential homologies between seed plants and pteridophytes. An understanding of the flower is reached by way of the pteridophytes.

The laboratory studies are planned to cover sufficiently the ground of a text book and the students by quiz work are held to a careful reading and understanding of the text, digging out for themselves the fundamentals of the subject. The lectures are chiefly upon subjects less satisfactorily treated in the text and the course endeavors to reduce formal lecture work to a minimum, substituting for it quiz and class discussion in sections of not more than twenty five students.

Some optional field trips are arranged for students willing to put in extra time but no attempt is made to attract the attendance of students with little or no interest in the subject since such are frequently disturbing elements in the success of field work.

With this the publication of outlines in the hands of the writer is brought to conclusion. The twenty which have been printed are a selection from more than twice as many received and fairly represent the diversity of conditions for which introductory courses in botany are framed and the radical differences of opinion as to material and methods. With conditions so varied in the schools and colleges it is clear that there can be no standardization of the introductory course. Progress will be made by experimentation and will be hastened with the interchange of experience and suggestion. It is hoped that the publication of these outlines has been of some help in this direction.

HIGHEST MOUNTAINS IN IDAHO.

Hyndman Peak is the only named mountain in Idaho that rises above 12,000 feet. It stands near the Blaine-Custer county line and has a height of 12,078 feet. There are, however, several unnamed peaks near Hyndman Peak whose elevations are greater than 12,000 feet, as shown by the contours on the Hailey topographic map, published by the United States Geological Survey.

PROMISING OIL WELLS IN SOUTH-CENTRAL ARKANSAS.

For the last few years geologists have conceded that oil and gas may be found in commercial quantities in southern Arkansas. The formations there are practically identical with those that yield oil and gas in northern Louisiana and the location of the area with relation to the Ouachita and Sabine uplifts indicates that there is in that area favorable anticlinal structure comparable to the anticlines beneath which the Caddo and Homer pools were formed. Development was retarded, however by lack of detailed mapping which would have shown the relations of the beds of southern Arkansas to those of Louisiana for it seemed possible that a fault, known as the Alabama Landing fault, which had been observed in northeastern Louisiana extended across southern Arkansas, and that the beds north of this fault had dropped down so far that the oil-bearing beds would be below the reach of the drill. Recent developments have shown that this fear is groundless, and there is now ample encouragement for active wildcatting in this region. The beds are of the same age as those that bear oil only a short distance to the south; the structural relations indicate that anticlines and domes should exist; and most important of all, tests have actually discovered good showings of oil and have developed gas in paying volume.

THE DISCIPLINE OF EXPRESSION.

BY MAX J. HERZBERG,
Central High School, Newark, N. J.

The recent discussion in SCHOOL SCIENCE AND MATHEMATICS as to the causes of poor English in the oral and written work produced in the science and the mathematics classroom fails, if I may say so, to consider one important aspect of the question —the psychology of expression. The problem turns on the nature of thinking as limited by its statement in words.

"What is thought?" asks Anatole France, "and how do we think?" And he replies: "We think with words." A person employing words is engaged in very definite mental processes, and some students of the human mind have confirmed Anatole France so far as to say that thinking itself does not exist until it has been formulated in language.

As one writer has stated: "People say sometimes, 'You know, I have an idea if I could only express it,' but they forget that thought is born in language and that thought does not exist without words, and that anything which cannot be expressed is not. They forget that consciousness only begins with a spoken communication, and that there is no such thing in the world for useful purposes as an idea that cannot be expressed, and the very usefulness which we have is limited to the possibilities of our expression. There is little use in being sincere if we cannot translate."

Language, as Jung in his "Psychology of the Unconscious" points out, should, however, be comprehended in a wider sense than speech. In other words, the whole process of intelligence is accompanied by an undertone of words, phrases, and sentences—broken or whole, continuous or disjointed. Apply this to the process of teaching; and it will be obvious how absurd it is to confine to one hour of the day the business of instructing students how to handle words. In the sentence of Robert Louis Stevenson, "The problem of education is two-fold; First to know and then to utter." To keep instruction in utterance within the bounds of the English period means merely that for only that single hour each day students are being instructed how to think.

It is impossible to teach a student the laws of the angles of a triangle or the parts of a flower or the mechanism of a pattern or the chemical constituents of food, without teaching him the use of words. No teacher can escape his destiny. In his zeal to impart merely the facts of his subject, he may deliberately

neglect the rules of clear and compact expression, for example. If he does he must inevitably find that the very facts he sought to teach have somehow been eluded by the student. It may then be laid down almost as a definition that in the so-called academic subjects, one of the prime objects of education is to train the ability to think clearly as shown in clear expression. The mother tongue in such a definition is merely the flexible medium of all expression, and is equally significant to all teachers at all times.

It may be inquired, What shall be said of the technical subjects? So far as the academic portions of such subjects are concerned—the recitation, the examination paper, etc.—no difficulty, of course, arises. But it is a common misconception that academic subjects involve high intellectual activities, whereas technical subjects do not. It may, on the contrary, be maintained that it is probably more difficult and not less difficult to understand the workings of a carburetor or the proper relations of the nutritive elements than it is to understand the construction of a Spenserian stanza or the principle of a subjunctive of purpose. The time may indeed come when a process only too familiar in our days will be reversed. In those revolutionary times the vocational counselor of the city's school system will come to a boy failing in a technical course and will say to him: "My boy, I am afraid you are not quite brainy enough for a technical course. You had better be transferred to an academic course or to an academic high school."

The only problem at present lies in the fact that the technical subjects have been for so short a time a part of the school curriculum that their intellectual content has not as yet been reduced to method. Here a proper realization of the value and conception of the mother tongue cannot but help. Teachers of technical subjects, just because these subjects are more difficult than academic subjects are, must more than other teachers insist on clear and careful expression.

I know the reluctance some teachers may feel with respect to receiving such a conception of the mother tongue. It may imply to them the constant and everlasting application of pettifogging rules and regulations, which hitherto they have left to English teachers, not without a profound sigh of relief. I admit that it is with a certain measure of complacency, on the other hand, that the English teacher would contemplate a wonderful state of affairs in which it would no longer be possible for the

student to abuse his e's and i's in *receive* when writing for the history teacher, and to reel off nonchalantly his "I seen" and his "I done it" to the gymnastics teacher, and then to come to his English teacher and regard him with wondering eyes as a queer fossil survival of the First Glacial Era. But I did not have these minor points particularly in mind. May I quote in this connection the words of Prof. Thomas H. Briggs of Teachers College, who says:

"It is felt by many that English teachers give to pupils an indelible impression that criticism means a hostile scrutiny of details, whereas the duties of life will demand of them positive merits—the manifestation in their compositions of such qualities as sincerity, definiteness, unity, coherence, variety, and the like. I myself have an ingrained horror of violating many detailed rules of dictation or of grammar, but sometimes I am heretical enough to wish that I had an equally ardent desire and the corresponding ability to master my subject, to seek the truth consistently in discussion, and to organize such thoughts as I have so that any intelligent hearer may perceive each one, fully understand it, and comprehend how in relation to the others it contributes to a worthy end." The ideal of the reader of compositions and of the hearer of recitations, in any subject, should be that of Baldwin: "To be a promoter rather than a proof-reader." Nor does cooperation with the English department mean, as one writer has put it, that the teacher in another department should pester pupils concerning such errors as he himself is conscious of not committing.

Nor is it necessary to be dogmatic as to special devices, the complete sentence in reply to questions, for example. What it is suggested teachers do, so far as teaching the mother tongue is concerned, is not to hunt with a microscope for grammatical errors, nor yet to insist on a rigid ceremonial in recitations, but rather to direct pupils' thinking on the plane of language. The average teacher, moreover, as he faces the average pupils, is not confronted with the task of helping in the development of literary geniuses. He is only to be properly conscientious as to the pupil's use of the mother tongue, and so far as his own subject goes, he is to demand a unified, methodical presentation of facts. The student consequently may learn more of the art of clear thinking and expression in the geometry class and more of the niceties of language in the Virgil class than he does in his contemporaneous English class. Moreover, as I know from

personal experience and observation, such is often the case. So the teacher in any subject may say to the student: "If you make grammatical blunders, it proves that you are not mature enough to realize the value of your mother tongue. We shall consequently keep you in your present English grade until you grow up. If, on the other hand, your presentation of the facts and principles of physics or cooking or mechanical drawing or economics is confused and obscure, it proves conclusively that you have been guilty of a crime of deeper dye—the crime of not understanding *me;* and so of course I shall certainly keep you here in my class for a sufficient period longer."

For the definite work of cooperation, the plan in use at the Cicero, Ill., high school seems the best. This, as it is described in accessible records, I recommend to the attention of interested readers.

OUTSIDE OF CLASSROOM ACTIVITIES IN SCIENCE.

By L. C. Feldmann, *High School, Oshkosh, Wis.*

W. L. Lane of the Survey Staff after a detailed study of the English school system under war conditions made the following statement:[1] "One good has, however, come out of all this"—referring to the use of school buildings for barracks—"and this is the *school journeys* that have been resorted to in order to fill in the time which can not be spent in the classrooms." Referring to a particular class, in which outside work had been done, he said: "Within six months the class had become so much more alert and interested in its work than it had been before, that the instructor begged to be permitted to continue these journeys even after the school had been restored to its educational use." In order to determine the extent to which these methods are employed, the following questionnaire was sent to Wisconsin High Schools, chosen at random out of the school directory issued by the State Department of Education.

Out of the forty-eight letters sent out, thirty-seven replies were received. In two cases the information obtained was of an indefinite nature, and consequently has not been included in the tabulations.

In answer to my request for personal letters only three schools, numbers 8, 11, and 36 responded. In each case the writer excused the small amount of outside activity because of the shortness of the periods and because of the prohibitive amount of work on the part of the instructor.

[1]Survey, Feb. 3, 1917.

Dear Fellow Teacher:

I am enclosing a set of questions which I wish you would fill out and return to me in the enclosed stamped envelope. If some of the subjects mentioned are taught by some other teacher, will you please obtain the information from that teacher, and then fill in in the proper spaces?

I should appreciate a personal letter stating more in detail what you are doing in the line of outside activities in connection with your science work.

1.

Class	Approx. Number of trips.	Where to are trips taken
Physics		
Botany		
Ele. Science		
Agriculture		

2. Is there a Science Club or similar club in your school?
3. If so, what is accomplished by it?
4. Number of members? (b) Number of pupils in school?
5. Are any attempts made to create an interest in science in pupils who are not taking any science subjects?
6. What are they?

In reply to the first excuse I can only say that if the periods are so short that trips cannot be undertaken in the allotted laboratory time, the curriculum has not been properly balanced, and should be rearranged. However, I have found a double period of forty minutes each affording ample time for all ordinary excursions. And under exceptional conditions different arrangements can be made. As for the teachers having too much work, if that is the case; then the teaching force should be enlarged, for we cannot afford to have the rising generation taught in a helter-skelter fashion. The problems the men and women of tomorrow will have to grapple with will be too difficult to solve with such a preparation as a foundation. However, it is my firm conviction that the overworked teacher would find relief in taking a physics class to the power plant or to the telephone exchange and have the person in charge of the plant explain the workings of the same. In order to prepare a lesson of this kind all that is necessary is to telephone for permission to visit the respective plants and arrange for a guide. Surely, this is not so much work and does not take as much time as is required in preparing the regular laboratory exercises.

Thus much for the excuses. More interesting conditions are revealed as the answers to the six questions are compiled.

Tables I and II take in all the data under question I.

In tabulating the results, the total obtained by adding the number of trips taken by each class in that subject was divided by the number of classes entering into the making of the total; thus giving the average. For example, in physics the thirty-

TABLE NO. 1.		NO. OF TRIPS TAKEN IN:			
School Number	Approx. Enrollment	Physics	Botany	Elem. Science	Agricultr.
1	70	4	10	4	7
2	39	1	2	0	3
3	265	1	3	0	8
4	20	4		0	7
5	90	1		0	2
6	65	0	2	2	3
7	83	2	5	0	2
8	105	1	0	0	10
9	120	2	6	2	6
10	125	1	0	5	
11	99	0	0	0	0
12	72	0	18	0	26
13	80	7	7	8	0
14	810	0	0	0	2
15	109	5	0	8	15
16	310	5	15	4	14
17	400	2	0	0	0
18	135	4	12	0	10
19	120				
20	800	3	4	4	50
21	270	4	4	2	7
22	75	1	12	4	3
23	46	1	3	0	8
24	240	4		2	2
25	25	0	0	1	3
26	95	2	7	3	6
27	75	1	0	1	
28		2	5	0	2
29	105	0	19	0	21
30	115	7	8	7	0
31	130	0	2	0	0
32	89	8	15	5	14
33	78	2	0	0	1
34	83	4	6	4	5
35	460				
36	216	1	0	0	1
37	280	4	10	3	4
Total No. of Trips		84	175	69	242
Average No. of Trips		2 2-5	5	2	7
No Trips Taken		7	10	10	5

five classes took eighty-four trips; or each class took an average of two and two-fifths trips. Seven, or one-fifth of the classes, undertook no trips during the year. In botany the average number of trips is five per class, yet ten teachers taught this subject for which much illustrative material in natural environment is always close at hand without any attempts to utilize it. Elementary science shows an average of two trips per class, but in this case, half the classes went on no trips. Agriculture, a subject which calls for much field work in order to get away from the non-vitalized type of instruction of ten years

Table No. II
Where Trips were Taken to by Class in:

Physics	Botany	Elementary Science	Agriculture
1. Electric Plant	1. Woods	1. Factories	1. Farms
2. Telephone Exchange	2. Field	2. Asylum	2. Feed Mill
3. Paper Mill	3. Truck Farm	3. Condensory	3. Elevator
4. Saw Mill	4. Greenhouse	4. Marble Works	4. Stock Farm
5. Dam	5. Lake	5. Coke Plant	5. Machine Shop
6. Garage	6. Fish Hatchery	6. Drug Store	6. Fair
7. Tractor Factory	7. Parks	7. Bakery	7. Corn Field
8. Machine shop	8. River or Brook	8. Photograph Gallery	8. Woods for Grafting
9. Water Plant	9. Orchard	9. Water Plant	9. Creamery
10. Power Plant	10. Garden	10. River or Brook	10. Gardens
11. Print Shop			
12. Telegraph Office			

ago, has an average of seven trips per class. Even here, five teachers have made no attempts to vitalize their work by this method.

In Table II a list of the places mentioned by the different teachers as having been visited by their classes has been made. Under physics twelve specific places are mentioned of which numbers 1, 2, 6, 8, 9, 10 and 12 are usually found in any village or city. Botany and agriculture have a very general list with probably numbers 3, 4, and 6 the only places not found in every community. In elementary science where ten specific places are mentioned and two are the average number of trips undertaken, some other reason for this lack of outside activity must be found. Keeping this in mind, note schools number 12, 13, and 29 in which the four subjects mentioned are taught by the same teacher.[2] Number 12 shows no trips in physics or elementary Science, 18 in botany and 26 in agriculture; number 13 gives physics 7, botany 7, elementary science 8, and agriculture 0; number 29 has the following record; Physics 0, botany 19, elementary science 0, agriculture 21. The records for schools numbers 12 and 29 seem to indicate that the teacher's particular field was agriculture and botany. Upon further inquiry this was found to be true.[3] In both cases the instructor had majored in agriculture in college. School number 13 has a record which points to agriculture as the slighted subject. And in this case it was found that the teacher had had no college or practical training in agriculture and taught the subject because the

[2,3] Verified by personal interview.

science man was supposed to do so. These results, although meagre, seem to indicate that a teacher can teach only those subjects in which special training has been received, and that some subjects are taught by teachers not adequately prepared to teach them. Now then, let us again think of elementary science. Perhaps in the fact that no special training to teach such a subject has been offered by the college and universities and that it has not been given much of a place on the sectional programs of the leading teachers' association meetings, can be found the reason for the poor record made by it. Or is it perhaps because elementary science, to a great extent, is taught by teachers who would rather work in their chosen fields; such as physics, botany, or agriculture?

In answer to question 2, six schools indicated that there was an agricultural club in the school, and thirty-one stated that they had no club of a scientific nature. One instructor in answer to this question made the following statement: "With a literary society and debating club it does not seem advisable." Here the impression is given that the attitude, "I'll take care of everything else first, and then comes science," prevails. What the clubs accomplished can best be judged by several answers to question 3 which follow: (1) meetings are held semimonthly and topics pertaining to agriculture and poultry are discussed by students; (2) discussion of current farm improvements and study of farm magazines; (3) garden and field projects are undertaken. In each case a marked improvement in alertness was noticed among the students belonging to the club.

The number of members ranged from 15 in the smallest to 40 in the largest club. The average membership for all the clubs was 28.

Like question 2, questions 5 and 6 do not net much information outside of the fact that very little is done outside of the classroom to interest students, and that a few are opposed to such methods. However, in sixteen instances the opinion expressed was that something not included in classroom work should be attempted. Often this opinion was expressed in unmistakable terms. For example, instructors in schools number 6, 14, and 25 answered thus (school 6): "Not as yet *but there should be*"; (school 14): "Outside work a sadly neglected feature here"; (school 25): "*No*, but something *ought* to be done." In a few schools some attempts are made. School number 9 reports that opening exercises are given over to the discussion of science subjects

one of the features being to have the person in charge give questions to be reported on later, the answers to these questions to be found in *Popular Science.* The instructor in school number 22 places newspaper and magazine clippings of scientific interest on a bulletin board and encourages students to bring to him clippings of the same nature to be placed on the board.

Both of these methods are very good and should be more generally used. However, in large schools such methods do not reach all the students, because no general assembly is held every day and not all students visit the class room where the bulletin board is found. Another very good way of reaching the pupils in a school of any size is by means of exhibits.

These exhibits, which will be explained later, should be placed somewhere in corridors near the main entrance, or better still if possible, in some particular place in the library. It is an advantage to place them on a small table or stand used exclusively for the purpose of the exhibition in some well-lighted space, but if necessary, less favorable positions afford sufficient opportunity. A bulletin board immediately behind the table or stand is convenient for pinning up clippings pertaining to the articles on exhibition. A fairly large card or label conspicuously placed on the table or near the top of the bulletin board, naming the project and indicating when changes in the exhibit are made is desirable. As a means of exciting the interest of those who do not take science it is advisable to change the display once a week, preferably on Saturday; but if there is a shortage of illustrative material, a two weeks period is not too long.

In order to help out in this respect the following list of exhibits used by the author and found of interest to the pupils is given:

1. (a) Cecropis moth. (b) Blazing Starflower. (c) Picture of song sparrow.
2. Asbestos and literature on same.
3. Horlick's malted milk exhibit.
4. Blue print pictures and how to make them.
5. The ores of different minerals.
6. X-ray picture and literature on electric treatments.
7. (a) Specimen of frog. (b) Several balls of cotton. (c) Picture of robin.
8. Coffee in various stages of preparation.
9. Several different specimens of fungi.
10. How to mount butterfly or moth (the various steps).
11. (a) Zebra swallow-tailed butterfly. (b) Several clams and oysters in the shell.
12. (a) Closed Gentian. (b) Giant water bug.
13. Standard Oil Products exhibit.
14. (a) Pickerel weed. (b) Sea urchin. (c) Picture of gold finch.
15. (a) Synthis moth. (b) Blue jay picture. (c) Starfish.
16. Collecting, pressing and mounting plants.
17. Collecting of rocks.

18. Artificial fertilizer and effect on plants.
19. How to prepare any small insect for permanent collection.

This list can be supplemented to a great extent. For example, the experimental field has not been touched and under this, besides many others depending on the laboratory apparatus on hand, the following can be shown:

1. Petri dish experiment to show presence of bacteria on different articles.
2. Testing of cloth for adulterations.
3. Copper-plating of a spoon or fork.
4. Illustration of the difference between an acid and a base by action on indicators.
5. Refraction of rays of light by means of a pencil placed so that it is partly under water.

In each case an appropriate non-technical explanation for each article was given on a four by six card. There was no pretense at arranging the exhibits in any definite order, for it was found advisable to have each exhibit complete in itself rather than have a course of exhibits. By experiment it was found that the present system created more interest in a larger number of pupils than the course of exhibits did.

In conclusion, I will say that I have tried to give to the reader in concrete form the data gathered from other teachers, together with my interpretations, and also those methods which I have found successful while teaching.

COMMERCIAL GEOGRAPHY AS VOCATIONAL GUIDANCE.

By Andrew Nichols,

Austin High School, Chicago, Ill.

The daily papers on a recent Sunday showed that the labor market of Chicago demanded men in the following vocations which might be classed as office work: Certified public accountants, cost accountants, senior accountants, bookkeepers, billers and extenders, ledger clerks, cost clerks, general office clerks, adjustment correspondents, addressers, foreign correspondents, mailing clerks, adding-machine operators, railway clerks, stenographers and typists, advertising men, credit and collection men and manager, clerks for insurance offices, bank clerks, placement men for employment agencies, office engineers, office managers, special credit men for banking houses, insurance executives, advertising managers, health and accident club managers, interpreters for professional offices, and time keepers.

In the mercantile field there were calls for buyers and assistant buyers, advertising solicitors, stock clerks and receiving clerks,

floor managers, billing department managers, window trimmers, sales managers who know United States from the distributing viewpoint, man for import and export trade, examiners, Chicago agent for N. Y. cotton house, shipping clerks, order fillers, and checkers in wholesale houses, order pickers in mail-order houses, district sales managers, salesmen both counter and traveling for groceries, hardware, fountain pens, jewelry, real estate, optical supplies, millinery, motion picture films, draperies, dress goods and silk, furs, shoes, talking machines, electrical appliances, automobiles, auto tires and accessories, drugs, bonds, candy, soap, toilet preparations, creamery and dairy supplies, lubricating oils, food products, pencils, washing machines, and vacuum cleaners: "Puff Waffle" merchants.

In the production world the following trades were in demand: templet makers, tinsmiths, tool makers, watch makers, welders, pattern makers, repair men, wood workers, assemblers, bakers, battery men, bench, floor and squeezer molders, blacksmiths, book binders, bushelmen, butchers, cabinet makers, compositors, cutters, pressmen, dick mailers, die makers, engravers, feeders, furniture grainers and finishers, gear cutters, glass workers, machinists, men skilled in marine engine construction, wood workers on musical instruments, meter testers, lathe men, iron and brass molders, linotype operators, scale men, spinners, soap makers, steam fitters, stationary engineers, tablet men, foundry superintendents, auto trimmers, auto mechanics, tailors, auto and machinery inspectors, and various classes of shop foremen.

Openings in the more strictly technical lines and professions were not as numerous. There were, however, some calls for architectural, topographical, tool designing, mechanical, and automobile draftsmen, electrician for motor and generating station work, engineers, designers, research technical men, teachers for electrical and automobile courses, commercial photographers and free-hand artists, dentists, attorneys, secret service men, appraisers, market reporters, and chauffeurs.

Some miscellaneous offerings, difficult to classify, are perhaps worth mentioning: Man for pawn-shop, man to learn theatrical scenery painting, man to instruct and teach the use of the moving-picture camera, men for the merchant marine, elderly man with white mustache and beard to act as Santa Claus.

The openings for boys showed much less differentiation than those for men. Boys were wanted for delivery work, errands,

order fillers, assistant shipping clerks, light electrical assembling, to stamp parcel post packages, to bind books, and as apprentices in various trades. The usual bait, an "opportunity to learn the business," was held out in a great many cases.

The demand for women and girls showed less minute classification than that for men, but more than that for boys. The demand was greatest for stenographers, bookkeepers, typists, filers, general office girls, cooks, house-maids, nurses, salesladies, cashiers, dictaphone operators, waitresses and seamstresses. There were scattering calls for addressers, circular folders, billers, assistants in doctor's offices, comptometer and multigraph operators, entry clerks, ticket writers, timekeepers, switchboard operators, photo engravers, book binders, mailers, foreladies, secretaries, women to sort and cut pickles, pack bakery goods, electrical assemblers, girls for filling, cartoning and labeling bottles, packers and wrappers, stock girls, paper flower makers, lamp shade makers, beauty shop operators, button makers, candy makers, designers, hat trimmers and manicurists, monotype operators, drapers, demonstrators, salesmanagers, music teachers, inspectors, industrial nurses, traveling salesladies, "Human Interest" librarian, and woman for vocational placement.

This bewildering array of positions open on one day in Chicago gives a fair picture of the business world as it appears to the boy or girl the day after graduation from high school. Is it not true that a man has two great decisions to make in life: One, the choice of his vocation; two, the selection of a girl to be his wife. (After these are made, she makes all the rest.)

I believe commercial geography is fitted to give the student much help in making the first of these decisions. If a commercial geography teacher, or anybody else, attempts to give a student too much so-called "guidance," either vocational or matrimonial, he will rightly fail. Business men make their own decisions. Boys and girls expecting to enter business must do the same. Vocational information, not advice, is what they want.

Information concerning the relative opportunities in the various vocations and the general distribution of the demand for labor in each is not obtainable in the average Chicago home today. It is therefore the function of the public schools to give the boys and girls this data before they are obliged to select their first regular employment.

As a means of experimentally discovering how much the average Chicago boy or girl knows about the real nature of

vocations, I unexpectedly asked the pupils in my classes one day to write a brief description of their fathers' work. To make it a fair test and to avoid diffidence, I told them they need not sign their names. Many freely admitted that they did not know their fathers' business. The reasons for this condition are not hard to find. Life in a large city is complex. Economic employments are not carried on in or near the home. Social engagements are very exacting. Office and shop employment has become highly specialized.

In less complex social and economic units, vocational information is much more easily obtained. Work is done nearer the home. The smaller the industrial unit, the more visible are its operations. The home life of the farmer has more influence on the children than the home life of industrial classes in the cities. The country boy or girl daily sees and comes in contact with all the vocations common to a rural community. This acquaintance with industrial activity must come to the city boy largely through the influence of the press, libraries and the schools.

If the school fails and the pupils are allowed to drift into work by chance or proximity, there is tremendous waste occasioned by the misfit of getting into the wrong employment. This results in a high percentage of inefficiency and change in the working force of every large concern, the waste of time, money and training and a general low grade of service. Every person who remains in the wrong employment is doomed to moderate usefulness and early incapacity. Usually, however, vocational misfits are corrected after much loss of earning and learning capacity in drifting from job to job while securing a knowledge of the world's work that could and should have been obtained at school.

Even after the drifting process has gone on for two or three years the final employment, though not a complete misfit, is often only a partial adjustment of ability and interest to resources and opportunity—a life investment much like the investment of money at a low rate of interest. The work that the individual would like to do best and at which he would be the most productive is side-tracked into the evening hours or pushed out of his life altogether. Life is worth more than money (anyway a person won't sell it); it should, therefore, be invested on the best return of the capital put in.

Of course, the object of all vocational guidance is to show the individual how to test himself in connection with his opportunities, to see where he can best invest his particular capital.

It is my own belief (maybe I am wrong) that such work in the past has laid too much emphasis on self analysis and too little on a careful survey of the larger relations of industrial and commercial life. Biographical data of leading business men today seems to show that the successful man is in the business that he is because he "likes it" and not because he showed any special qualifications as a boy for his particular work. Associations formed on various summer jobs covering the last fifteen years have convinced me that the converse of the proposition is also true—that the reason for the misfit is that he "hasn't found anything that he likes." Efficiency and success are largely a matter of interest.

Interest or lack of interest in any particular vocation or business is more likely to be due to knowledge or ignorance than to demonstrated capacity. This will often explain why an Illinois farm boy who knows all the "outs" of his father's business comes to Chicago and is lost in the mass of moderately successful industrial workers, while a Chicago boy who knows something of the intensity of city competition in industrial lines, leaves real opportunity, goes into the country and settles down to earn money to buy the farm that the country boy would have gotten by inheritance. Such relations as the above are clearly within the sphere of commercial geography instruction.

Commercial geography explains the world in terms of its usefulness to man. It is the point of contact between the sciences dealing with nature and social sciences. It is a study of the interdependence of the different parts of the world and the influence of location on the industrial and commercial life of man. Its primary object is not to teach vocations as such, but industries and commerce, and right here, I believe, lies the great opportunity of the commercial geography teacher for vocational guidance, because the great mass of the business of a large city depends on distant markets or distant sources of raw material and food products, and the dignity of an occupation is only felt as its relation to other occupations and regions is known.

I don't believe you can do a better service to boys and girls than to get them interested in industries rather than trades merely, for here is the point where ambition starts. Stenography and tool-making are not vocations for ambitious boys, although I don't believe there are any better means than these to use as entering wedges for forcing one's way into commerce or manufacturing. The idea "once a stenographer always a

stenographer" is not the basis of a wise vocational decision. If boys and girls, before going to work, get a larger interest in their chosen industries, they are more likely to feel a loyalty to their companies and less inclined to indulge in the luxury of quitting several jobs before finally settling down. This loyalty to the industry rather than the trade as a unit, which comes from interest and interest from knowledge will go a long way toward preventing industrial unrest and, incidentally, will go a long way toward the vocational advancement of the individual boy or girl concerned.

In order for boys and girls to get an accurate view of the world's commerce and industries from their work in commercial geography, that work must be in an environment of business and business journals. In a great national and international trade center like Chicago, opportunities for this are unsurpassed.

The first fundamental of commercial geography is exchange. Exchange is dependent on transportation and Chicago is the greatest railroad center in the world. Transportation and the exchange of commodities has become a science and there are almost infinite vocational opportunities attractive to a high school boy or girl as something worth working for in the administration of the general offices of a great railroad system or a large city passenger, or freight depot. Entire classes cannot readily be taken through such places, first, because of their numbers, and second, because it is wasteful to use the time of forty people to accomplish a result which can be gotten better by two. Here is a working plan: Two pupils are given a typewritten letter of introduction, directed to the highest official in the building, asking him to give them a guide to show them how the work in the general offices of a large railroad is carried on, so that they can tell their class about it. The two pupils are given a few simple instructions as to what to observe, two of these instructions being to try to see what the different classes of employment are and what seems to be the principal work of each. Often the guide will help them in this. These pupils make a formal report to their class. In my own classes I have had many reports of this kind which were very interesting and enlightening from the vocational guidance viewpoint. For example: My pupils have observed in practically all of the industries studied that men of all ages were employed but that there are only young women. This has given them visible proof of the economic fact that men should train themselves for

one vocation, and women for two; first, a temporary employment of a few years and latter a permanent employment, in most cases, as homemakers. I believe that a study of the sources of the world's supply of the commodities daily used in the home and the various channels of commerce through which they pass in getting to the consumer's door is good vocational training for any American girl.

Another significant fact which my students have noted is the large percentage of employees in a commercial market like Chicago who are engaged in the buying and selling of goods. Clerical training of the business college or "clerk factory" type does not train to buy and sell goods.

Another thing of still greater importance which they have discovered is the relatively small number of men in business who are products of the commercial courses in our high schools. This is only another angle of the situation disclosed in the commissioner of education's report of any year in the table on commercial education; where we find that Chicago has a surprisingly low percentage of boys taking commercial courses in the high schools, as compared with other large cities. Ex-Mayor Harrison's commission on commercial education noted the same fact and recommended the building of a central commercial high school in Chicago, which would train boys as well as girls for business.

The movement of commerce in and through Chicago presents many phases of our peculiar geographical environment which can be utilized to light the way to vocational opportunity. The largest packing houses in the world are here, offering a hundred different grades of responsible employment, varying from office and clerical positions to representatives in foreign markets or buyers in South America.

Some of the largest wholesale houses in the country are on Franklin and Market Streets, illustrating the specialized forms of employment to be found in a great distributing center.

The harvesting machines of the world are made in the plants of the International Harvester Company and there the student in commercial geography can learn at first hand the work and the requirements of the various specialized vocations connected with world trade.

The mail order business made profitable by the parcel post is revolutionizing the retail business of the country, an illustration of the ever-changing adjustments which are being made in the

field of commercial geography, and here again the Chicago boy or girl who sees a life opportunity in mail order work can learn at first hand by the laboratory method.

One of the phenomena of commercial geography is the gathering together of great masses of people in centers of general industry like Chicago. Such a vast population means a great and varied local market. The department stores and smaller retail units afford a ready means of studying this phase of business activity with especial reference to the vocational opportunities which it presents.

Although the influence of accumulations of capital and financial institutions is not, strictly speaking, a physical condition of commerce, most writers of commercial geography treat them as within the sphere of the subject because their geographical situation is often a determining factor in the location of industrial units and commercial establishment. The Federal Reserve, National, and State banks of Chicago have many attractive openings for boys and girls who are more interested in banking as a life work than in the question of initial salary.

This only illustrates the possibilities for field work as a part of commercial geography instruction. The class is a clearing-house into which are brought the various items of vocational information and interest which are gathered by the different groups of pupils as they visit these and many other units of commercial activity as their study of the topics of commercial geography brings them home to Chicago.

We are fortunate in having other means of creating interest in the industries which go to make up our economic life. Mr. Hayes, at the Board rooms, thru the liberality of the Board of Education has been enabled to get together a very complete collection of sets of lantern slides illustrating commercial geography. These slides have been collected with an idea of instruction rather than entertainment, and many of them furnish vocational information. Seeing them on the screen is almost equivalent to going thru the establishments which they portray.

To be of the greatest value as vocational guidance, commercial geography must not only have an outside environment of business; it must also be in an immediate environment of business journals. We are preparing the great majority of our pupils for business and not for the university. The business man gets his information from technical and trade journals, not college text books. If commercial geography teachers overlook

this fact, they are neglecting the very best means of vocational guidance. Such journals are: "The Daily Trade Bulletin"; "The American Grocer"; "International Sugar"; "The Tea and Coffee Journal"; "The Iron Age"; "Black Diamond"; "American Lumbermen"; "American Wool and Cotton Reporter"; "Shoe and Leather Facts"; "India Rubber World"; "American Machinist"; "The Electrical World"; "Engineering and Mining Journal" and the more general magazines like "The World's Work" and "Technical World"; also the Reader's Guide, an index of magazine articles.

The commercial geography teachers of Chicago and elsewhere are using these and other means to give their students a view of the commercial world before they choose their vocations. It is a large field. Mr. Vanderlip, the great banker, once said: "The eye of every business man must be far-seeing enough to observe all markets and survey all zones. A significant word spoken in any market place or parliament of the world instantly reaches the modern business man and he should be prepared correctly to interpret its meaning."

THE MATHEMATICS OF ELEMENTARY PHYSICS.

BY PHILO F. HAMMOND,

University of Wyoming, Laramie.

The body of a fish weighs thirty pounds, the weight of its head is twice that of its tail, and its body and tail together weigh three times as much as its head. How much does the fish weigh?

A farmer has a square farm enclosed with a fence four boards high. If the boards are eleven feet long and the farm contains the same number of acres as there are boards in the fence, how many acres are there in the farm?

To the casual observer the above problems are intended for exercises in algebra, but while it is possible that they could be used as such, they are not from that source. They are problems taken from a list that were used by our grandfathers as exercises in arithmetic in the old log school house, and while the second one may have been worked with pencil and slate, the first one belongs in the category of what was known as "mental arithmetic." Such problems have gone out of use so far as arithmetic is concerned, and perhaps rightly so since they have very little practical value. However, the pupil of those days received a training in analytical and independent thinking that our present system does not seem to give the pupil of today.

But what has this to do with mathematics in elementary physics? Only this: The writer believes that the analytical method applied to problems in arithmetic in those days should be applied to the mathematics in elementary physics rather than the formula method too commonly used.

Of recent years there has been on the part of teachers in our high schools, administrators and others much complaint against so-called mathematical physics in our high schools. Not only can these complaints be heard in our schools and at teachers' associations, but they are used as a basis of articles in magazines and as arguments against the kind of questions used for college entrance examinations. They are directed against textbooks and teachers of physics in general and especially against the training given such teachers in our colleges and universities. Some writers have even gone so far as to say that they would choose the physics teacher from the untrained in physics so as to get away from the sort of training given to the prospective teacher by the higher institutions.

Let us see how well these complaints are founded. Some physics texts will disclose the astonishing fact that about ninety-five per cent of all mathematics used in elementary physics is arithmetic, and it is safe to say that the teachers are few indeed who make their courses more mathematical than the books present the subject. In these texts there are but one or two simple quadratic equations used, and these in connection with accelerated motion. Many problems, to be sure, may be worked by either arithmetic or by the use of the algebraic method, but even if algebra is used, the equations are of the simplest form with only one unknown quantity. There are a few cases where geometry is applied, but these involve only a simple proof that two triangles are similar because they have equal angles and being similar their sides are proportional. Beyond this a fair notion of variation, as applied to such topics as Boyle's law and Charles' law, is required.

In our American high schools physics is seldom taught below the eleventh grade, and before entering the class in physics practically all high school students have covered two thirds of the algebra usually given in the high school and all of plane geometry, and, as has been pointed out, the mathematics used in elementary physics is very simple in its nature, involving but few simple principles in algebra and geometry. If one takes all of these facts into consideration, together with the fact of

the large amount of complaint against the mathematics in elementary physics, if there were no other conditions to be considered, one would be forced to come to one of the following conclusions: (1) Students cannot be expected to get anything out of high school mathematics except such mental discipline as may come from their work in the class room, and one has no right to expect them to use what they learn in the mathematics class room outside of that room; or (2) teachers of mathematics in the grades and in the high school do such poor work that their students are unable to apply what they learn in the mathematics class to any concrete problem outside. There is hardly any one who will concede the first proposition, but if we do not, is not the complaint against mathematics in elementary physics rather a condemnation of the mathematics teaching in our elementary and secondary schools than a condemnation of physics texts and physics teaching? It cannot be considered unfair for chemistry and physics teachers to expect their students to be able to use the principles of mathematics which they have studied, and if the student ever expects to use what he has learned, there is no better place than in the physics and chemistry classes for him to begin to do so.

It is not, however, the aim of the writer of this article to lay any blame to mathematics teachers, and while much might be said in regard to methods of improving the teaching of mathematics, it is not the intention of the writer to discuss this phase of the question as such. What is said regarding mathematics in physics will apply, perhaps, to mathematics in general, but this article is written for physics teachers, and not for mathematics teachers.

Going back to the problem above, students of arithmetic in those days applied what the writer prefers to term the "think method" rather than the method of formal mathematics. They followed through the problem using a method of reasoning which led them to the correct result without the use of symbol or algebraic equation. The mathematics teacher may say that this is useless kind of thinking, and perhaps it is since the problem itself may be classed as a useless kind of problem, but it gave exercises in the thinking process which when applied to various problems enabled the student of those days to solve problems that would bother many of the high school students of today. This "think through," or analytical method, should be the method applied to the solution of problems in elementary

physics. To illustrate this method one or two examples will be sufficient.

The physics teacher should not hesitate to teach the mathematics he wishes to use, no matter how much he may expect of the mathematics teacher. The application of Hooke's law is a good chance for the physics teacher to emphasize the principles of variation. This may best be done beginning with a concrete example. The following is data taken with a Jolly balance for a class for that purpose.

Pull of the spring in grams:	Elongation of the spring in centimeters:
1	5.9
2	11.9
3	17.9
4	23.7
5	29.7
6	35.5
Total 21	124.6

Examination of this data will show the student at once that the elongation increases as the force increases, and, therefore, $F_1/F_2 = E_1/E_2$. That is, F is proportional to E or $F = k \cdot E$. Whence $k = F/E = 21/124.6 = 0.1677$ gram or that it takes 0.1677 gram to stretch the spring one centimeter.[1] To test this if we multiply 29.7 by 0.1677, we get 4.98+ grams, or nearly five grams, the quantity given in the table. Also $2/4 = 0.500$ and $11.9/23.7 = 0.502$, that is to say $F_1/F_2 = E_1/E_2$, or $2/4 = 11.9/23.7$ approximately. The application of this principle to physical problems will be clearer to the beginner if we call his attention to the fact that this is not a new thing. If ten yards of cloth cost $1.50, what will 25 yards cost? 30 yards? etc. After a few questions of this kind, the following table may be made:

Quantity of cloth in yards. (Q.)	Cost in cents (C.)
1	15
2	30
3	45
4	60
5	75
6	90
Total......21	315

Then we may say $C_1/C_2 = Q_1/Q_2$ or $2/4 = 30/60$ and C is proportional to Q or $C = kQ$, and likewise $k = C/Q = 315/21 = 15$ cents, and the constant is, therefore, the price per yard. When

[1]For the beginner this (force) constant should be determined by asking the question: "If 21 grams stretches the spring 124.6 centimeters, what force will be required to stretch it one centimeter?" For the sake of brevity only an outline of the development is given here.

possible these facts should be developed by questions before any algebraic expressions are used.

Accelerated motion is considered to be one of the most difficult parts of elementary physics. In many texts this is placed among the first topics in mechanics of solids, and when mechanics of solids is studied before mechanics of fluids, the student is confronted with a hard topic early in the course. The subject of accelerated motion will not seem especially hard to the elementary student if properly approached. The student is already more or less familiar with the idea of velocity. If a train runs between two stations 120 miles apart in four hours, how far does the train travel in one hour? The answer is quite obvious to most students—even to pupils in the grammar school. If a train travels at the rate of thirty miles an hour, how far will it travel in four hours? If a train runs for four hours at the rate of thirty miles an hour, how far will it go? The answers to these questions are equally obvious. No formulae are necessary. Attention should be called to the fact that what is meant is average velocity, that the train varies in velocity, and also that when we use the term velocity we infer a given direction as well as magnitude of the velocity.

This part of the discussion completed we may resort to an experiment if we so desire. The space that a ball rolls down an inclined plane may be determined for one, two, three, four, etc., seconds. The difference between these spaces is the space traversed by the ball for each unit of time. That is, the space covered by the ball from the beginning to the end of the first second, and from the end of the first second to the end of the second second, etc., etc., is the average velocity of the ball for that respective unit of time since it is the space covered in that unit of time. It will be seen that these average velocities are not equal, and if we get the difference between the first average velocity and the second average velocity, and between the second and the third, etc., etc., we have the increase in velocity per second which experiment shows in this case is practically a constant. This constant, or increase of velocity per unit time, we call acceleration. However, it is not the aim of the writer to discuss the experimental part of this topic. The nature of the experiment will depend upon the apparatus available. In whatever way we may approach the subject, the important thing is that acceleration is increase or decrease of velocity per unit time, or, to be more concise, change of velocity per unit

time is acceleration. If the thermometer registered thirty degrees twelve hours ago and now it stands at seventy, what is the change of temperature? What is the average change per hour? If the velocity of a moving body is twenty-four feet per second, and four seconds later it is 152 feet per second, what is the change of velocity? What is the change per second? If the velocity of a moving body increases at the rate of thirty-two feet per second, what will the total increase be in four seconds? If the student has not been handicapped by learning the formulae, he will follow this line of reasoning without difficulty, and no formulae or symbols are necessary.

We now enter the second stage of development; viz., to determine the space covered by the moving body. We have already shown that space is the average velocity multiplied by the time. The question now before us is to determine the average velocity. The average of anything is obtained by adding all of the quantities, the average of which is desired, and dividing by the number of such quantities added together. At this point it is well to resort to a diagram. Suppose we plot a curve with velocities as ordinates and time as abscissae. Since the velocity is increasing uniformly, the velocity is proportional to the time, and the curve, therefore, is a straight line. By means of this curve it is easy to show the student that there may be an infinite number of velocities, but in spite of this we may get an average, since the change of velocity is uniform. In this case it can easily be made clear that the same result may be obtained by taking the velocity at the beginning, and at the end of each second following, and we have $(0+32+64+96+128) \div 5 = 64$ feet per second. (Some student will probably suggest that if we take the velocity at the "half way" point, we will have the same result.) From this we can easily lead the student to see that if the first and the last velocities are taken the same result will be obtained, and thus we have $(0+128) \div 2 = 64$ feet per second. If the average velocity is 64 feet per second, how far then will the body travel in four seconds?[2]

Next let us suppose that the velocity at the beginning is twenty-four feet per second and the increase in velocity is thirty-

[2]The writer used this method of presenting accelerated motion ten years ago, and did not think of it as a new method, but had not seen it given in this way in any of the elementary text books, although some of the advanced texts use the substance of this method. Recently in looking over "Practical Physics" by Black and Davis he noticed for the first time that they use this method in developing the formulae for accelerated motion, but give the credit to Professor E. V. Huntington of Harvard University and consider it an entirely new method.

two feet per second; how far will the body travel in four seconds? The velocity at the end of each second is easily obtained from our diagram and the average velocity obtained as above is $(24+56+88+120+152) \div 5 = 88$ feet per second, or $(24+152) \div 2 = 88$ feet per second, and the space is $88 \times 4 = 352$ feet. So far, and not a formula nor a symbol used.

During all of this discussion the teacher has been using the term "thirty-two feet per second per second" without any explanation. Some student in the class will ask why the second "per second" is used. This is not taken up, however, until the subject is fairly well developed. Then the question is put: "If a body is moving at the rate of twenty feet per minute and increases its velocity to 120 feet per minute in a period of ten seconds, what will we say the acceleration is?" The students will give the correct answer at once.

Following this discussion the students are sent to the blackboard to work problems in accelerated motion, but no formulae are used. The writer has used this method for several years. It works well with students who have not studied physics before, and who have not learned the formulae. If the student has already learned the formulae, the task becomes difficult if not impossible. If there are students in the class (usually a small per cent) who have been well trained in algebra, and who have the algebraic conception fairly well developed, they will develop their own formula from this process of reasoning, and they will begin at once to use it. If the teacher so desires, he may, after giving a sufficient number of numerical problems, give problems using symbols instead of numbers and thus all of the members of the class will have developed the formulae. This should not be done, however, until a sufficient number of numerical problems have been worked to fix the principles thoroughly. With this method problems in which the initial velocity is not zero become as simple, even to the beginner, as problems usually given in elementary textbooks.

With problems involving the relationship $v = \sqrt{2}$ as this method becomes a little too difficult for the student to work the problems quickly and with ease. Such problems, if worked at all, should be left to the last. They may be worked without the use of the formula, but it is better, however, to develop the formula for the class.

Hooke's law as applied to the Jolly balance, and accelerated motion have been chosen as examples only, and have been

given in some detail to make the method clear. Accelerated motion was chosen as an example because it is usually considered as a difficult topic. It can be treated without the use of formulae, and with the student of elementary physics it is much better to so treat it. To be sure, students at this stage of development should be able to handle the elementary principles of formal algebra without much difficulty, but for the sake of the physics we as physics teachers cannot afford to use it in elementary physics more than is absolutely necessary. The student may need more training in the use of algebraic equations, but from our standpoint as teachers of physics it is the physical concept that he needs most, and that is usually what he does not get —especially if he learns a formula.

In physics, therefore, the "think method" is the one that will give the best results. With this method the student learns to think in terms of physics. It is a training, not a mere memory process, that will stay with him as long as he lives. The formal algebraic method depends upon the student's memory, so far as physics is concerned; if he forgets the formula as he will sooner or later, his physics disappears with it. The writer would prefer a text in elementary physics, if such a text could be had, with no formulae given, or with the formulae taken out of the body of the text and placed in a table in the back of the book so that the student could not study them in connection with the assigned topics. As it is he sometimes finds it necessary to caution students against studying certain parts of the text until that topic has been completely covered in the class.

The subject of physics has been developed by a few individual thinkers of exceptional ability—Galileo, Stevinus, Newton, Gilbert, Franklin, Faraday, Maxwell, and the others—who took the trouble to put the results of their thinking to the experimental test. Their thinking, of necessity, began with real concrete facts. Formal mathematics has, to be sure, played a tremendous part in the development of this subject; it has in many cases preceded and predicted important scientific discoveries as in the case of the Hertzian waves. However, the fundamental principles upon which Maxwell based his equations came from Faraday who used only the "think process" and who used no equations. Likewise the student who is just beginning in the subject must begin with concrete facts associated with the thing he already knows, and if he actually gets a grasp of the subject, he must follow pretty much the same process that the

pioneers followed, but his road, of course, need not be so long and tedious. Clear thinking must precede any attempt to use mathematical equations, much thinking must accompany any use of mathematics whatever and all must be put to the experimental test not after, but as an aid to, the thinking process. Description of apparatus and of how it works, of machines and how to operate them, or how to repair them if they get out of order may be of value, and courses of this nature may possibly have their place in the school curricula, but such a course should not be called physics for it is not a science unless the fundamental underlying physical principles are studied and in such a way that the student is required to do much individual thinking in applying these principles; and there is no better way, in fact hardly another way, to obtain this individual thinking on the part of the student than to require the application of these principles not only to problems that do not require a mathematical solution, but to a large number of problems that do require a mathematical solution. This can and should be done in the laboratory and in the recitation.

Summary:

Is elementary physics too mathematical?

By no means; the mathematics in elementary physics is after all mostly physics and arithmetic. Physics requires the student to think, unless it is the purely descriptive kind of physics that some teachers are trying to substitute for real physics to avoid thinking.

Do students like the mathematics of physics?

If properly taught, yes; unless they do not like to think. Some students do not; like many older people some either have not the ability, or are too lazy.

Does it pay to lead students to think?

Yes, there was never a time in the history of the world when real able thinkers were needed in all lines of work as much as they are today.

What then is the matter with the mathematics of elementary physics?

Too much formal algebra without application. Not enough of the "think process" used. It is easier for the teacher to require the student to learn the formulae than to actually teach the subject. It is a short cut for the student—the path of least resistance. It is a means of avoiding real thinking and therefore followed, unfortunately, by too many teachers.

PASCAL'S "NEW EXPERIMENTS ON VACUUM."

TRANSLATED FROM THE FRENCH BY WILLARD J. FISHER,

Woods Hole, Mass.

A letter of Pascal to M. de Ribeyre, "Premier président de la Cours des Aides de Clermont-Ferrand," is dated July 12, 1651, in which he complains that in the "Prologue" of certain theses on philosophy, read in the judge's presence, June 25, 1651, he had been accused of appropriating credit for the Toricellian experiment. He says:

"In the year 1644 some one wrote to Rev. Fr. Mersenne, Minimite at Paris, that the experiment we are discussing had been done, without specifying in any way who was its author. So in fact he remained unknown to us. Fr. Mersenne tried to repeat it at Paris, and, not being entirely successful with it, he stopped and thought no more about it. Then, having been at Rome on other business, and being exactly informed as to the means of carrying it out, he returned thence fully instructed.

"This news having been brought us at Rouen, where I then was, in the year 1646, we did this Italian experiment according to the directions of Fr. Mersenne, and having been entirely successful with it, I repeated it several times; and being by this frequent repetition entirely assured of its truth, I deduced from it consequences, to test which I did new experiments very different from that one, in the presence of more than five hundred persons of all sorts and conditions, and among them five or six Jesuit fathers of the College at Rouen. . . .

"To render to others and myself justice due, I had printed, in the year 1647, the experiments which I had done a year earlier in Normandy."

The above and the following are translated from Vol. III of Pascal's works, the edition of Hachette, 1872.

The "complete treatise" mentioned was never completed; only fragments of it are known.—[WILLARD J. FISHER.

TO THE READER.

My dear reader, certain considerations hindering me from publishing at present a complete treatise, wherein I have reported a quantity of new experiments done by me on vacua, and the consequences which I have drawn from them, I have decided to give an account of the principal ones in this abstract, in which you will see in advance the plan of the whole work.

The occasion of these experiments is as follows:

It is about four years since an experiment was tried in Italy thus: a glass tube about four feet long, with one end open, the other hermetically sealed, being filled with quicksilver, then the opening closed with the finger or otherwise, and placed perpendicular to the horizon with the stopped opening downward, is plunged two or three fingerbreadths into some more quicksilver contained in a vessel filled half with quicksilver, half with water; if the opening be unstopped, remaining the while submerged in the quicksilver of the vessel, the quicksilver in the tube will descend partly, leaving in the upper part of the tube a space empty in appearance, the lower end of the same tube remaining full of the same quicksilver up to a certain height. And if the tube be raised a little, so that the opening, previously

dipped into the quicksilver of the vessel, leaves the quicksilver and comes into the region of the water, the quicksilver in the tube ascends with the water to the top of the tube, and the two liquids are mingled in the tube; but finally all the quicksilver falls, and the tube is altogether full of water.

This experiment having been reported from Rome to Rev. Fr. Mersenne, he announced it in France in the year 1644, not without exciting the admiration of all savants and amateurs. As by their reports it became famous everywhere, I learned of it from M. Petit, superintendent of fortifications, a man well versed in *belles lettres*, who had heard of it from Rev. Fr. Mersenne himself. At Rouen, therefore, we did together, this M. Petit and I, the same as had been done in Italy, and we found detail for detail what had been reported from that country, without then observing anything new.

Then, reflecting by myself on the consequences of that experiment, I confirmed myself in the idea wherein I had always been, that a vacuum was not a thing impossible in nature, and that she did not avoid it with as much horror as many have imagined.

What forced me to this idea was the slight foundation which I saw for the maxim so generally received, that nature does not suffer a vacuum; which is based upon experiments for the most part entirely false, although held entirely reliable; and of the rest, some are far removed from contributing anything to the proof, and show that nature abhors too great congestion, and not that it avoids a vacuum; and the most favorable prove nothing more than that nature has a horror of a vacuum, and not that it cannot suffer one.

To the weakness of this as a principle, I would add the observations which we daily make about the rarefaction and condensation of the air, which, as some have shown, can be condensed even to the thousandth part of the space formerly occupied by it, and expands even so strongly; which I considered as necessarily so, either because there is much empty space between its parts, or because there is penetration of dimensions. But since the world as a whole did not accept this as proof, I believed that this Italian experiment was capable of convincing even those most biased as to the impossibility of a vacuum.

Nevertheless, the force of prejudice always finds objections which take away deserved credit. Some say that the top of the tube is full of the vapors of mercury; others talk of an imper-

ceptible granulation of rarefied air; others, of a kind of matter which does not exist outside of their imagination; and all, conspiring to outlaw the vacuum, emulate one another in that faculty of the mind which they call subtlety in the schools, and which in the solution of real difficulties gives nothing but vain words without foundation. I therefore resolved to do experiments so convincing as to be proof against all possible objections; of such I made a great number at the beginning of this year, some of them related to the Italian experiment, others entirely unrelated and having nothing in common with it. They were so exact and so satisfactory that by their means I showed that a vessel as big as can be made can be rendered entirely empty of all the kinds of matter which fall under our senses, or which are known in nature; also what force is necessary for producing a vacuum. Moreover, I tested the height necessary for a siphon to produce the effect expected of it, above which limiting height it no longer acts, contrary to the opinion so universally held in the world through so many centuries; also the small force needed to draw the piston of a syringe, without any matter taking its place; and many other things which you will see in the complete work; wherein I design to show the force employed by nature to avoid a vacuum, and how she actually allows and suffers it in a large space, which is easily made empty of all forms of matter which fall under the senses. Hence I have divided the complete treatise into two parts, the first containing at length an account of all my experiments, with figures, and a recapitulation of what they mean, divided in several maxims; the second, the consequences which I have deduced from them, in several propositions, wherein I have shown that space apparently vacuous, as it appeared in the experiments, is in fact empty of all the forms of matter which fall under the senses or are known in nature. In the conclusion, I give my ideas on the subject of vacuum, and reply to possible objections. So, I content myself with demonstrating the existence of a large vacuum, and I leave it to savants and scientists to find out what happens in such a region; as, whether animals can live there; whether glass in it diminishes its refractive power; and everything one can do there; not mentioning this in the treatise, of which I have thought to give you this abstract in advance, since, having made these experiments at much expense and spent much trouble and time, I feared that somebody else who had not spent the time or the money or the pains, anticipating

me, might give to the public facts of which he was not a witness, and so which he could describe with the accuracy and the order necessary for proper deductions; no one having had tubes or siphons as long as mine, and few being willing to take the trouble to have them.

And since honorable people join to the general inclination of all men, to defend themselves in their just possessions, also that of refusing honor not due them, you will no doubt approve me likewise, defending myself against those who would wish to deprive me of any of the experiments which I here give you or promise you in the complete treatise, for they are my own invention; and against those who would attribute to me that Italian experiment just described, since it is not mine. Although I have done it in more ways than anyone else, with tubes of twelve and even fifteen feet long, nevertheless I will not speak of that alone in this, not being its inventor; as I have no design of giving what is not my own, the fruit of my own ingenuity.

Abstract of the First Part, Wherein Are Described the Experiments.

Experiments.

I. A glass syringe with a well-fitting piston is plunged entirely into water, and its opening is closed with the finger, so as to touch the piston at the bottom, for this purpose the hand and arm being put into the water; one has need of only a moderate force to withdraw the piston and separate it from the finger, without the water entering in any way, (something the philosophers have believed could not be done with any finite force); then the finger is felt to be strongly and painfully drawn in; the piston leaves a space empty in appearance, into which it does not seem that anything can have got, since it is completely surrounded with water that can have had no access, the opening being closed; if one draws the piston farther out, the space empty in appearance becomes greater, but the finger feels no greater suction; and if one removes the syringe almost entirely from the water, so that only the opening remains immersed with the finger closing it, then on removing the finger the water, contrary to its nature, rises with violence and entirely fills the space vacated by the piston.

II. A bellows thoroughly tight on all sides does the same thing with similar precautions taken, against the belief of the same philosophers.

III. A glass tube forty-six feet long, with one end open and the other hermetically sealed, filled with water, or better with red wine, for better visibility, is then stopped and in that condition raised and placed perpendicular to the horizon with the stopped open end down, immersed about a foot in a vessel full of water. If the opening is unstopped, the wine in the tube descends to a certain height, about thirty-two feet above the level of the water in the vessel, runs out and mixes with the water in the vessel, which it colors slightly, while it separates from the glass at the top, leaving a space about thirteen feet long, apparently empty, where it does not seem as if anything could have got in. If the tube be tipped, then the height of the wine in the tube decreases by the inclination, the wine ascends till it reaches the height of thirty-two feet; and if finally the tube be tipped just to the height of thirty-two feet, it is entirely filled, sucking in moreover the water which had been ejected by the wine; so that it is full of wine from the top to thirteen feet from the bottom, and full of water slightly tinted in the thirteen feet below.

IV. A siphon with unequal legs, the longer fifty feet, the shorter forty-five, is filled with water and the two openings stopped and placed in two vessels of water, each immersed about a foot, so that the siphon was perpendicular to the horizon, and the water surface in one vessel is about five feet higher than that in the other; if the two openings be unstopped with the siphon in this condition, the longer leg does not draw the water from the shorter, and consequently not from the vessel in which it is, contrary to the beliefs of all philosophers and artizans; but the water falls in the two legs standing in the two vessels, to just the same height as in the tube just described, reckoning the height from the surface of the water in each vessel; but after inclining the siphon below the height of about thirty-one feet, the longer leg draws the water from the vessel of the shorter one; and on raising it above this height, this stops, and both the two sides discharge, each into its own vessel; and on lowering, the water in the longer draws the water in the shorter, as before.

V. If into a fifteen-foot tube sealed above at one end and filled with water there be put a fifteen-foot cord with a thread attached to its end (this is to be inserted into the water slowly, so that it may take it up little by little—air might somehow be enclosed in it), so that there is nothing outside the tube

except the thread attached to the cord for drawing it out, and if the opening be immersed in quicksilver, when the cord is withdrawn little by little, the quicksilver rises proportionally, until the height of the quicksilver, added to the fourteenth part of the height of the remaining water, is two feet three inches; then, as the cord is pulled, the water leaves the top of the tube, and leaves a space empty in appearance, which continually increases as one keeps on pulling the cord. If the tube be inclined, the quicksilver of the vessel enters, so that, with sufficient inclination, the tube is entirely filled with quicksilver and water which strikes the top of the tube violently, making the same sort of noise or report as if the tube were broken; and, in fact, it does run a risk of breaking. To get rid of the little bit of air, which, so to speak, is lodged in the cord, one can do the same experiment with a number of little wooden cylinders, attached together with a brass wire.

VI. A syringe with a perfectly fitted piston is put into quicksilver so that its opening is immersed at least an inch and the rest of the syringe stands perpendicularly outside; if the piston be drawn, the syringe remaining as described, the quicksilver enters through the opening of the syringe, rises and remains in contact with the piston until this has gone up in the syringe two feet three inches; beyond this height, if the piston be drawn still farther, it does not draw the quicksilver any higher, but this leaves the piston and remains constant at this height of two feet three inches; so that there is made a space empty in appearance, which becomes greater in proportion as the piston is drawn further. It is probable that the same thing happens in a suction pump, and that the water rises in this only to the height of thirty-one feet, which corresponds to two feet three inches of quicksilver. More remarkable is this: that the syringe, if weighed in this condition, without removing it from the quicksilver or moving it in any way, has the same weight, although the space apparently empty be as small as desired, as when, withdrawing the piston farther, we make this space as large as we choose, and that it always weighs the same as the body of the syringe together with the quicksilver contained at the height of two feet three inches with not any apparently empty space—that is, when the piston has not yet left the quicksilver in the syringe, but is at the point of breaking away from it if pulled ever so little. So that the apparently empty space, although all the bodies about it tend

to fill it, causes no change in weight, and that, whatever be the differences in size among such spaces, there is none among the weights.

VII. A siphon, whose long arm is ten feet, short arm, nine and a half, is filled with quicksilver and its two openings put into two vessels of quicksilver, each immersed about an inch, so that the quicksilver surface in one is about a half-foot higher than that in the other. When the siphon is perpendicular, the long arm does not attract the quicksilver from the short; but the quicksilver, breaking at the top, descends in each arm and empties into the vessels, and falls to the usual height of two feet three inches, measured from the surface of the quicksilver in each vessel. If the siphon be inclined, the quicksilver mounts again from the vessels into the tubes, fills them and commences to flow from the short arm into the long, and so empties its vessel. For this inclination of the tubes, wherein is the apparent void, when they stand in any liquid, always draws the liquids from the vessels, if the openings of the tubes are not closed, or draws the finger, if it closes the openings.

VIII. The same siphon is completely filled with water, and then with a cord, as above, the openings being put into the same two vessels of quicksilver; when the cord is withdrawn by one of the openings, the quicksilver ascends from the vessels into both the two arms, so that the fourteenth part of the height of the water in one arm, together with the height of the quicksilver which has ascended in it, is equal to the fourteenth part of the height of the water in the other, together with the height of the quicksilver which has ascended in it. The result is that this fourteenth part of the height of the water, together with the height of the quicksilver in each arm, is a height of two feet three inches; for then the water divides above, and there is formed an apparently void space.

From these experiments, and many others reported in the complete book, wherein are seen tubes of all lengths, sizes and shapes, filled with different liquids, variously immersed in different liquids, carried from some into others, weighed in various fashions, and wherein are described the different attractions felt by the finger closing the tube with the apparent void, there are deduced readily these maxims:

Maxims.

I. That all bodies show a repugnance toward separation one from another, and to allowing an apparent void between

them, i. e., that nature abhors this apparent void.

II. That this horror or repugnance of all bodies is no greater toward allowing a large void than a little one; i. e., for separation by a large interval than by a small one.

III. That the force of this horror is limited, and equal to that with which water of a certain height, about thirty-one feet, tends to flow downward.

IV. That bodies which bound the apparent void have a tendency to fill it.

V. That this tendency is no stronger for filling a large void than for a little one.

VI. That the force of this tendency is limited, and always equal to that with which water of a certain height, about thirty-one feet, tends to flow downward.

VII. That a force greater, but as little greater as one chooses, than that with which water of a height of thirty-one feet tends to flow down, is enough to cause the sufferance of this apparent void, even as large as one may wish; i. e., to cause bodies to be disunited by an interval as great as one may choose, provided that there is no other obstacle to their separation or displacement except the horror which nature has for the apparent void.

(There then follow eight propositions denying the existence of a plenum of various imagined sorts, and asserting that the "space void in appearance" of the preceding actually contains no known kind of matter, real or hypothetical, including vapors of liquids; then an abstract of the conclusion expressing this opinion, thus:)

Having demonstrated that no sort of matter falling under our senses, and of which we have knowledge, fills this space void in appearance, until somebody shall have shown the existence of some kind of matter filling it, my opinion will be that it is really empty, and destitute of all matter.

Wherefore I shall call that a real vacuum, which I have shown as an apparent vacuum, and I will hold for true the maxims given above, and enounce them for the absolute vacuum as I have for the apparent, thus:

(Here follow the maxims above, but with the word "apparent" omitted from connection with "void" or "vacuum." And, finally, the statement of and reply to certain objections.)

Objections.

I. That the proposition that there is empty space is repugnant to common sense.

II. That the proposition, nature abhors a vacuum, and nevertheless allows it, accuses nature of impotence, which implies a contradiction.

III. That numerous experiences, even everyday, show that nature cannot suffer a vacuum.

IV. That an imperceptible matter, unheard of and unknown, to all the senses, fills such a space.

V. That light being either an accident or a substance it is not possible for it to exist in a vacuum, being an accident; and it fills that space void in appearance, being a substance.

A GEOMETRIC RECREATION.

By Isabel Harris,

Richmond, Va.

In the Collegiate School for Girls of Richmond, Virginia, a class in plane geometry, consisting of twenty girls, bubbling over with an unusually effervescent enthusiasm, planned this unique and fascinating modification of the usual contest in geometry.

The members of the class got together and divided themselves into two groups and each group selected in an animated voting contest one of their number to be captain. These two captains with the instructor were asked to form a committee to draw up the regulations that should govern the contest, and the following resolutions were submitted to the class:

I. There shall be a series of six contests in Math. IV during the months of December, January, February, and March.

II. The class shall be divided into two teams, consisting of a captain and nine members. The names of the teams shall be the Pythagoreans and the Platonians.

III. The instructor in mathematics shall referee the contest.

IV. Each team shall elect an official score keeper.

V. The propositions to be proved shall be selected by the referee and shall be written on the board one at a time.

VI. The first trial of the first proposition shall be decided by lot and shall thereafter alternate with the two teams.

VII. When a proposition is given by the referee, the captain shall appoint a member of her team to attack it. If she gives a logical proof, that side scores two points. If she fails to give

a proof, the captain can call on another member of the same team. If she proves the proposition, the team scores one point. If she fails to prove it, the opportunity of proving the proposition goes to the opposing team. The opposing team proving it scores one.

VIII. When a member of one team fails to give a correct proof, that member is disqualified for the day.

IX. A member having proved a proposition is not entitled to another trial until all other members have been given an opportunity to attack a proposition.

X. An illogical proof detected by the opposing team at end of proof shall score one-half point for that team.

XI. Any interruption of the one proving a proposition, either by her own team or the opposing team before she has reached the Q. E. D., shall be considered an "error" and shall score one-half point for the opposing side.

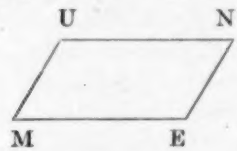
XII. At the close of the contest the team having the highest score shall be guests of honor at a "feast" given by the losing team.

....Captain of Platonians.
....Captain of Pythagoreans.
....Referee.

The regulations were received with a suppressed and tense enthusiasm, and were adopted by a unanimous vote. The contests followed in rapid succession and the interest was kept up by a careful selection of original exercises, beginning with simple propositions and continuing by easy ascents to more difficult ones. The teams were well matched and the competition was spirited. First one team and then the other was ahead, and the whole school watched with increasingly eager interest the outcome of each contest. Intercollegiate basket ball games and the World Series in baseball were no more discussed and rose to no higher point in the scale of school interests than the score of the Pythagoreans and the Platonians.

The Pythagoreans were the final victors and the Platonians evolved this clever scheme of giving them a mathematical "feast." Mystic invitations written on paper oiled with Wesson oil to represent parchment and rolled like scrolls, bade the guests to the party. They were greeted at the door by Plato's ominous motto printed in big, bold letters: "Let no one ignorant of geometry enter here." Guests and hostesses were all seated at one long table, which was elaborately decorated with vases

of "flowers" made by tying various mathematical symbols cut out of pink crepe paper to small bushy branches of shrubs. Over the table were scattered other symbols and the candle shades were decorated with weird and fantastic mathematical expressions. On the place cards were drawn familiar geometric figures. The following menu was served. Since the reader can not have the opportunity of verifying the menu by the courses served, an interpretation is given below.)



Given:

Proper Fractions
(Lettuce)$^{-1}$

Quadrilaterals — Triangles

Extracted Roots

. . . .

Homogeneous Cream@ $+32°F$
+Cake made by Heron's Formula
Cylinders with ‖ Lines.
Champagne (Imaginary)
H_2O (Real)

To prove that the Pythagoreans are equal to any occasion.
(Hint. Prove by elimination of hypothesis.)

Time Limit ∞

Interpretation
Given:

Chicken salad over lettuce

Saltines — Sandwiches

Saratoga chips

Ice cream
and cake
Society mints

Mr. Evershed thinks that the values of the color indices assigned by Prof. N. H. Russell to the sun and Venus (+ .79 m. and + .78 m.) are mutually inconsistent, since they imply that no selective absorption takes place in Venus's atmosphere. Mr. Evershed finds evidence of decided selective absorption in the violet, as compared with his cloud spectra.—*Nature* (London), Feb. 19, 1920, p. 675.

U. S. GEOLOGICAL SURVEY ESTABLISHES RESIDENT GEOLOGIST IN SAN FRANCISCO BRANCH OFFICE.

J. M. Hill of the United States Geological Survey, has been transferred from Washington to the Survey's office in San Francisco where he will be associated with Charles G. Yale. Mr. Hill's field of geological studies will include the Pacific Coast States and to some extent also Arizona and Nevada. The desirability of having a geologist attached to the San Francisco office has long been felt, for many requests for examination and report are received that can not be met by sending a Federal geologist across the continent.

THE GRAPHICAL SOLUTION OF SPHERICAL TRIANGLES.

BY MYRON O. TRIPP,
University of Maine, Orono, Me.

It is quite common to teach plane trigonometry in such a way that the graphical solution of plane triangles parallels the computational solution carried out by means of tables. The object of this article is to show that the same parallelism may be performed in the spherical trigonometry, that is, all spherical triangles may be represented in such a way that the remaining parts in the solution may be determined graphically. We may, therefore, check computational solutions in spherical trigonometry on the drawing board. An especial advantage of solving spherical triangles by drawing plane figures is that the student gets much drill in connecting spherical geometry with spherical trigonometry, and thus obtains a clearer understanding of both subjects.

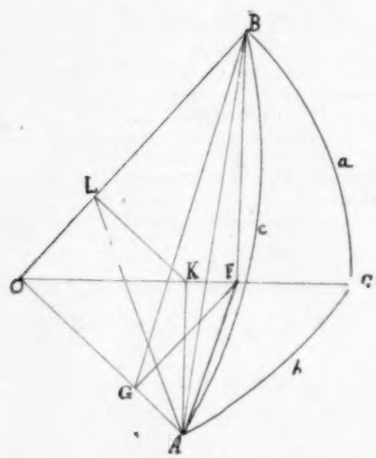


Fig. 1

For the greater part, the proposed graphical solution amounts to a correlation of spherical trigonometry and descriptive geometry. In some of the cases, however, it has been thought best to depart from the methods of descriptive geometry. The descriptive geometry involved in what follows is so simple that it is hoped that everything may be understood without assuming a previous knowledge of that subject.

Case I. Given two sides a and b of a right spherical triangle, to determine graphically the remaining parts.

In Fig. 1 the triangle is drawn in perspective. Let us call the plane through O (the centre of the sphere), B and C, that is, the plane through the side a, the vertical plane, or, in short,

the V-plane; and the plane through b the horizontal, or H-plane. Imagine now the H- and V-planes hinged about OC, and the H-plane turned through 90° downward, into the V-plane. Fig. 1 becomes Fig. 1 (a), the two figures being related in such a way that to the unprimed letters in the former correspond primed letters in the latter; or we may turn the V-plane 90° backward into the H-plane, likewise making Fig. 1 pass over into Fig. 1 (a).

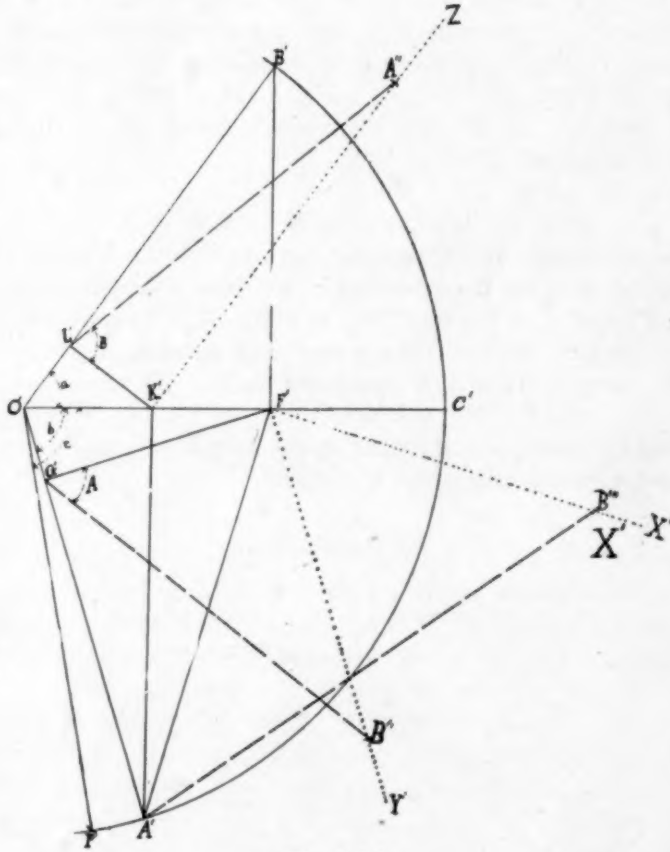


Fig. 1 (a)

In Fig. 1, BF is perpendicular to OC and FG is perpendicular to OA. Hence, $\angle BGF = \angle A$

Similarly $\angle ALK = \angle B$,

AK and KL being perpendicular to OC and OB respectively.

The graphical solution is now carried out as follows: On O′C′,

and above it, construct at O′ an angle equal to *a*. Likewise, below O′C′ construct an angle equal to *b* at O′. From B′ drop a perpendicular B′F′ on O′C′, and from F′ a perpendicular on O′A′ meeting it in G′. We next revolve GFB about GF into the H-plane. This is accomplished by drawing at F′, F′Y′ perpendicular to F′G′, and laying on F′Y′ the distance F′B″ = F′B′. Thus the triangle GFB, when laid down in the H-plane, becomes G′F′B″. Hence,

$$\angle FGB = \angle F'G'B'' = \angle A.$$

To determine the angle B we turn the triangle ALK about LK into the V-plane, that is, we drop from A′ a perpendicular A′K′ upon O′C′; and then from K′ drop a perpendicular K′L′ upon O′B′ from K′. At K′ draw the line K′Z′ perpendicular to L′K′, and on it lay off K′A″ = K′A′.

Hence we have

$$\angle K'L'A'' = \angle KLA = \angle B.$$

To determine the hypotenuse *c* we revolve the triangle AFB about AF into the H-plane, that is, we draw F′X′ perpendicular to A′F′, and on it lay off F′B‴ = F′B′. A′B‴ is now the true length of AB. With C′ as a centre, and radius equal to A′B‴, strike an arc cutting C′A′ produced at P′. We then have

$$\angle P'O'C' = c.$$

Case II. Given *a* and *c*, that is, the hypotenuse and one side, to find the remaining parts.

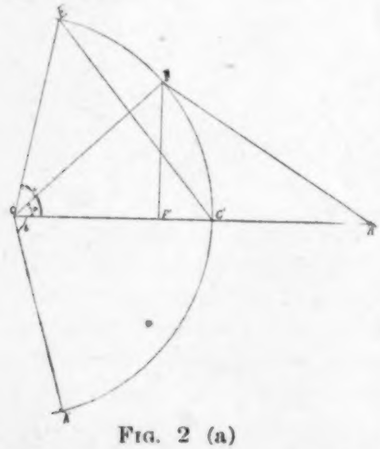


Fig. 2 (a)

We start with Fig. 1 and pass from that to Fig. 2 (a) just as we passed from Fig. 1 to Fig. 1 (a) in Case I. On O′C′ construct an angle C′O′B′ equal to *a*, and C′O′E′ equal to *c*. Thus the line C′E′ is the true length of AB. Using C′E′ as a hypotenuse

and B′F′ as one side construct the plane right triangle F′B′A″, that is, we have B′A″ = E′C′. Hence F′A″ is the true length of FA. With F′ as a centre, and radius equal to F′A″, cut the arc B′C′ produced in A′. Therefore the distance from F′ to A′ equals FA.
Hence,

$$\angle A'O'C' = b.$$

The remaining parts may be found as in case I, since we now know two sides

Case III. Given a and A in a right spherical triangle, that is, a side and the angle opposite, to find the remaining parts.

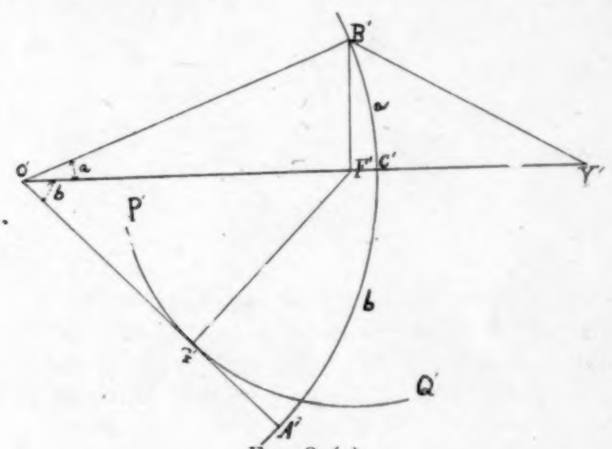


Fig. 3 (a)

Let us use Fig. 3 (a) and Fig. 1 as in the previous cases. Construct the angle C′O′B′ equal to a. From B′ drop a perpendicular B′F′ on O′C′. With the angle A and side B′F′ construct the plane right triangle B′F′Y′, that is, we make

$$\angle F'B'Y' = 90^\circ - \angle A.$$

With F′ as a centre, and radius equal to F′Y′, describe the arc P′Q′; and then from O′ draw O′A′ tangent to the arc P′Q′. Hence we have

$$\angle A'O'C' = b.$$

This operation amounts to constructing the triangle FGB in the V-plane and then rotating the triangle about F′B′, so that Y′ describes the arc of a circle in the H-plane, and then stopping the triangle in the position of FGB as shown in Fig. 1.

Since we have found b, the remaining parts may be found as in Case I.

Case IV. Given the side a and the adjacent angle B in a right spherical triangle, to construct the remaining parts.

Figures 4 and 4 (a) are related to one another just as 1 and 1(a)

In the V-plane construct the angle C′O′B′ equal to a. At L′ any point on O′B′, draw in the plane a perpendicular to O′B′

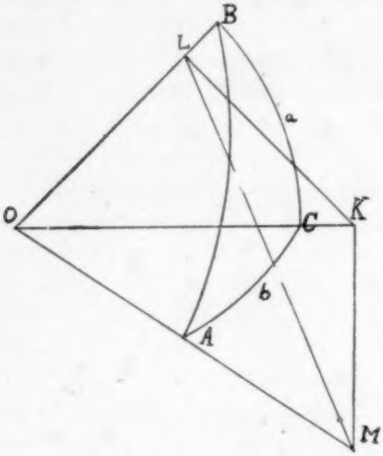


FIG. 4

cutting the intersection of the H and V planes in K′. With L′K′ as a side and angle B as an adjacent angle construct the plane right triangle L′K′M″. From K′ draw, in the H-plane, a perpendicular to O′K′ and lay off on it K′M′ equal to K′M″. Connect M′ and O′. Then

$$\angle M'O'K' = b.$$

Having now two sides a and b we can proceed just as in Case I to find the remaining parts.

Case V. Given the hypotenuse c and the angle A adjacent to it, to construct the remaining parts.

In Fig. 5(a) lay off the angle B′O′A′ equal to c. At A′ draw a tangent to the arc B′A′, and produce O′B′ until it cuts this tangent in T′. Using A′T′ as the hypotenuse of a plane triangle and the angle A as one of the acute angles, construct the right triangle A′Q′T′. In Fig. 5 this triangle is shown in perspective as AQT. TA and QA being perpendicular to OA, $\angle TAQ = \angle A$.

We next construct a right triangle with the two sides A′Q′ and A′O″ (= A′O′). This triangle is shown in Fig. 5 as OAQ. Hence

$$\angle A'O''Q' = b.$$

The remaining parts may be found by Case II or case IV. However, a convenient way of finding a is as follows:

Let us construct a plane right triangle with $O''Q'$ and $Q'T''$ ($= Q'T'$) as sides. This triangle is shown in Fig. 5 as OQT. Hence,

$$\angle Q'O''T'' = a.$$

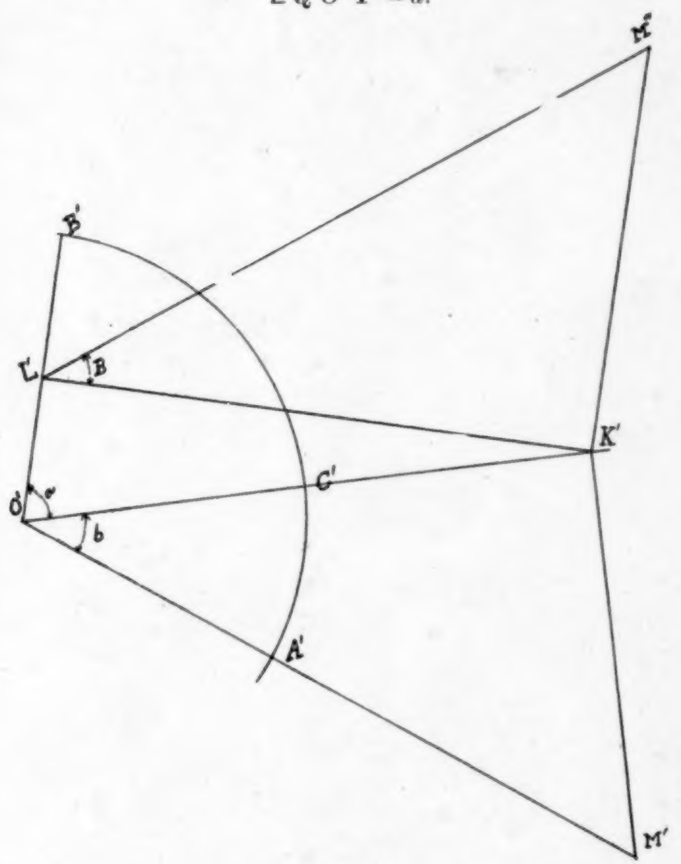


FIG. 4 (a)

Case VI. Given two angles A and B of a right spherical triangle to construct the remaining parts.

In Fig. 6 the triangle $A_1B_1C_1$, drawn in perspective, is the polar of the triangle ABC, the latter triangle not being shown.

Produce A_1B_1 and A_1C_1 to meet in G, thus forming another triangle B_1C_1G. Draw tangents to the arcs C_1B_1 and C_1G at C_1 and produce them to meet OB_1 and OG produced in D and E respectively. Then the angle DC_1E is supplementary to the angle $B_1C_1A_1$, and hence,

$$\angle DC_1E = c.$$

By means of the triangle DC_1E we propose to construct an angle equal to c. In Fig. 6(a) lay off a distance $O'C_1'$, $= OC_1$,

and at O′ lay off a_1 and b_1', a_1 being equal to (180− ∠A) and b_1' being equal to $(180-b_1)$ (= ∠B).

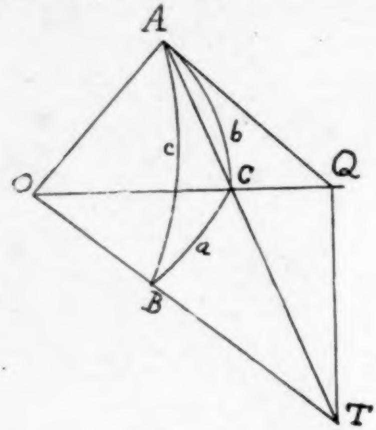


FIG. 5

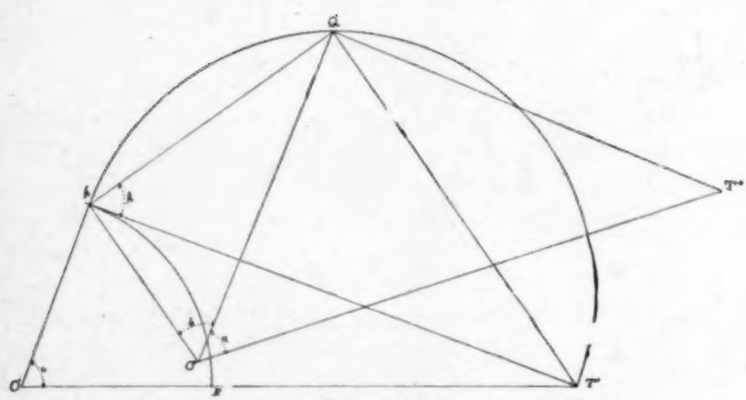


FIG. 5 (a)

To the triangle OC_1D of Fig. 6 corresponds the triangle $O'C_1'D'$ of Fig. 6(a); while to OC_1E corresponds $O'C_1'E'$. We have thus found as the true lengths of C_1D, OD, C_1E and OE the segments $C_1'D'$, $O'D'$, $C_1'E'$ and $O'E'$ respectively.

With $O'D'$ and $O'E'$ and the included angle of 90° we construct the triangle $O'E''D''$; thus $D''E''$ is the true length of DE. If now we construct a plane triangle with the sides $D''E''$, $C_1'D'$, and $C_1'E'$, viz. $D''E''C_1''$ we have

$$\angle D''C_1''E'' = c.$$

Knowing c and A we can proceed as in Case V to find the remaining parts.

Oblique triangles. When three angles are given we may pass

over to polar triangle just as in case VI for right triangles, and solve exactly as in that case. If three sides are given we may solve without using the polar triangle.

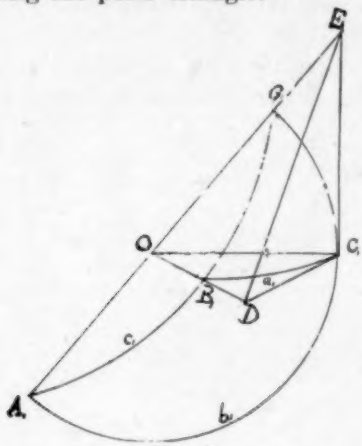


FIG. 6

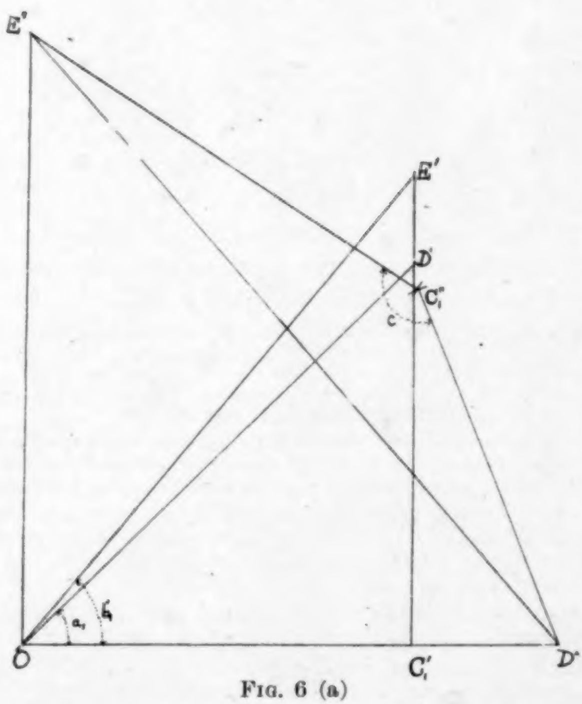


FIG. 6 (a)

When two sides, *b* and *c*, and the included angle, A, are given we solve by dropping a perpendicular arc from C upon AB as in Fig. 7 thus dividing the given triangle into two right triangles.

From b and A we can find all the parts of the triangle ACD. Then using CD and DB in the triangle DCB we can find all the parts of CDB. From the parts of the triangles ACD and BCD we easily determine the parts of the triangle ABC. By using the polar triangle the case in which a side and two adjacent angles are given is easily solved in the same way.

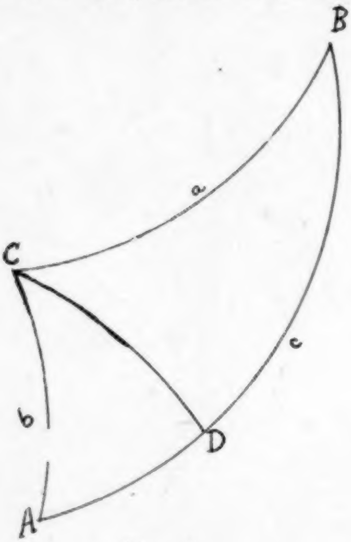


FIG. 7

When two sides and the angle opposite one of them are given e. g., a, b, and A, we can solve by right triangles (see Fig. 7) just as in the preceding case. Also the case of the two angles and the side opposite one of them can be solved by going over to the polar triangle.

ASBESTOS CAN BE FINE SPUN.

The earliest use of asbestos was for spinning and weaving, to make incombustible thread and yarn rope and cloth, and this has continued to be the most important use of asbestos ever since the days of the Greeks and Romans. Only the best grades can be used for this purpose, according to J. S. Diller, of the United States Geological Survey, Department of the Interior. Thread can now be spun so fine that it will run about 32,000 feet to the pound.

MAP OF COAL FIELDS OF THE UNITED STATES.

The United States Geological Survey, Department of the Interior, is now distributing a large map showing the coal fields of the United States. This map, which measures 4½ by 7 feet, shows the coal fields by a s ries of colors indicating the seven different kinds or grades of coal as it is classified by the Geological Survey—anthracite, semibituminous, high-grade bituminous, low-grade bituminous, lignite, and coking coal. The map is sold by the Geological Survey for $1, or for 60 cents each if five or more maps are ordered together. Besides the coal fields this map shows all the cities, railroads, lakes, and other features that are found on a map of this size.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

656. *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABC is an isosceles triangle, AB = AC; and AE is a line not cutting the sides of the triangle. A point D on AE is chosen so that BD = BC and ∠ADB = 150°. Prove ∠DAB is one-third of ∠DAC.

I. *Solution by Louis Sklav, Student at the Drexel Institute, Philadelphia.*

AB/sin150° = BD/sinBAD. But since sin150° = 1/2,
sinBAD = BD/2AB = BC/2AB.
Also, sin(BAC/2) = (BC/2)/AB = BC/2AB.
Then, ∠BAC = 2∠BAD or ∠BAD = ∠CAD/3.

II. *Solution by J. H. Packham, Owen Sound, Canada.*

Draw AF⊥BC, and BE⊥AE. AF bisects BC and ∠BAC. △EDB has angles 30°, 60°, 90°. Then EB = BD/2 = BF so that △s BAE and BAF are congruent. Hence ∠EAB = ∠EAC/3.

Also solved by N. Barotz, New York City; A. Pelletier, Montreal, Can., and W. R. Warne, State College, Pa. (3).

657. *Proposed by Walter R. Warne, Pennsylvania State College.*

If $x^2 = a^2+b^2$, $y^2 = c^2+d^2$, show that $xy > (ac+bd)$.

Solution by A. Pelletier, Ecole Polytechnique, Montreal, Can.

We have successively,

$$(ad-bc)^2 > 0, \text{ if } ad \neq bc,$$
$$a^2d^2+b^2c^2 > 2abcd,$$
$$a^2c^2+b^2d^2+a^2d^2+b^2c^2 > a^2c^2+b^2d^2+2abcd,$$
$$(a^2+b^2)(c^2+d^2) > (ac+bd)^2,$$
$$x^2y^2 > (ac+bd)^2,$$
$$|xy| > |ac+bd|.$$

Also solved by N. Anning, Ann Arbor, Mich. It should be noted that the solution is not really complete unless mention is made that $ad \neq bc$, (try $a = 3$, $b = 4$, $x = 5$, $c = 6$, $d = 8$, $y = 10$), and that absolute values must be considered in the final equation. Even when omitted in the statement of a problem, no mathematician should be satisfied with his solution until all the possibilities have been considered.

658. *Proposed by the Editor.*

Given two points A and B. Find, using only dividers, two points C and D so that ABCD will be the corners of a square.

I. *Solution by F. A. Cadwell, St. Paul, Minn.*

With A as a center and AB as radius, describe a circle O. With B as a center and AB as a radius, describe a circle O′, intersecting O at E and F.

With E as center and EF as radius, describe arcs intersecting O at H and O′ at G.

With A as center and EF as radius, describe arc JK. With B as center and EF as radius, describe an arc intersecting JK at I.

With G as center and GI as radius, describe an arc intersecting the circle O at D.

With H as center and HI as radius, describe an arc intersecting the circle O′ at C.

Two other points C′ and D′ opposite C and D can similarly be found for a second solution.

Proof: (As the proof is rather long, the editor has cut out all except the main facts.) Regard AB as a unit length, and let L be its midpoint. Then EF = $\sqrt{3}$ = EG = EH, so that H, A, B, G lie on a line and are a unit apart.

In $\triangle$LIG, $LI^2 = BI^2 - LB^2 = EF^2 - LB^2 = 3 - 1/4 = 11/4$.

And, $GI^2 = LI^2 + LG^2 = 11/4 + 9/4 = 5$.

In $\triangle$ADG, $AD^2 = DG^2 - AG^2 = GI^2 - AG^2 = 5 - 4 = 1$.

II. *Solution by James Clarke, Junior at San Jose (Cal.) High School.*

With A and B as centers and AB as radius, draw two circles intersecting at G, and by the usual arcs find E diametrically opposite B, and F opposite A.

Using E and F as centers and EB as radius, draw arcs intersecting at O.

Using A as a center and AO as radius, draw an arc intersecting AGF at C; and with B as a center and BO as radius, another arc intersecting EGB at D.

C and D are the required points.

Proof (abbreviated by the editor): Regard AB as a unit, and let H be its midpoint. Then EO = EB = 2. EH = 3/2, and in $\triangle$EOH, OH = $\sqrt{7}/2$. And in $\triangle$AOH, AH = 1/2, OH = $\sqrt{7}/2$ so that AO = $\sqrt{2}$ and hence AO can be used as a diagonal for the square. (The proof that the triangles are right triangles has again been omitted by the editor. The symmetry of the constructions also proves that the resulting figure could not be a rhombus.)

III. *Solution by A. Pelletier, Montreal, Can.*

With radius AB and centers A and B, describe two arcs intersecting at E; with the same radius and center E, describe an arc cutting AE at G and BE at F; with radius FB and centers F and G describe two arcs intersecting at H. Finally, with radius EH, and centers A and B, describe arcs cutting AEG at C, and BEF at D, the required points.

Proof: FE = AB; FH = FB = AB$\sqrt{3}$. Hence in the right $\triangle$FEH, EH = AB$\sqrt{2}$. Therefore, $AB^2 + BC^2 = EH^2 = AC^2$ and so $\angle$ABC = 90°.

IV. *Comment by the Editor;*

The first solution depends on the finding of a line whose length is $\sqrt{11}$, then $\sqrt{9}$, then $\sqrt{5}$, using the last as a diagonal. The second solution finds $\sqrt{7}$, then $\sqrt{2}$; and the last one depends on $\sqrt{3}$, then $\sqrt{2}$. The first requires 8 arcs, the second 10, the third 8. Another method for finding $\sqrt{2}$ is the following: Draw circles with A and B as centers and AB as radius; call E and F their intersection points, and G the point diametrically opposite A. Then with A and C as centers and EF as radius, draw two arcs intersecting at H. BH = $\sqrt{2}$.

The writer knows only of one method which does not involve finding a diagonal, but it requires 26 arcs resulting in an inaccurate figure. If A and B are the given points, we can find points E, F, G, H on a line with AB and at unit intervals. If they are drawn to the right of B, then AF = 3, AG = 4, AH = 5. With F as a center and 5 for a radius draw an arc; with A as a center and 4 for a radius, draw an arc intersecting the previous one at I. With G as a center and 5 for a radius draw an arc; with A as a center and 3 for a radius draw an arc locating the point J. Then the points I and J are a unit apart and on a perpendicular to AB. The point diametrically opposite I on the unit circle with center J is the desired point D. Instead of numbers 3, 4, 5 we could use 5, 12, 13 but the points corresponding to I and J would be 7 units apart, necessitating further work.

659. *Suggested by H. C. Whitaker's comment on problem 645.*

Prove geometrically that if R = $2r$, the triangle is equilateral.

I. *Solution by H. C. Whitaker.*

The distance d between the centers of the circumscribed and the inscribed circles is $d^2 = R^2 - 2Rr$. Hence when $R = 2r$, the circles are concentric, and the half angle of the triangle is 30° making the triangle equilateral.

II. *Solution by W. R. Warne.*

It is known that $R = abc/4\triangle$, and $r = \triangle/s$. If $R = 2r$, then $abcs = 8\triangle^2$ and the triangle is equilateral by problem 645.

Also solved by J. H. Packham, A. Pelletier. Several of the solutions received assumed that the two circles would be concentric. Again, neither of the two solutions above are strictly geometric; a geometric proof would involve a proof of Euler's relation $d^2 = R^2 - 2Rr$, a question which was raised some time ago in problem 415.

660. *Proposed by Martha G. Lathrop, Emmett, Idaho.*

Given three unequal non-intersecting circles O, O′, O″. Let A be the intersection point of the common external tangents of O and O′, B the point for O′ and O″, C the point for O″ and O. Prove A, B, and C are collinear.

I. *Solution by Thomas E. N. Eaton, Redlands (Cal.) High School.*

If r, r', r'' are the respective radii, we have

$AO/AO' = r/r'$ $\quad BO'/BO'' = r'/r''$ $\quad CO''/CO = r''r.$

Then $AO \cdot BO' \cdot CO''/AO' \cdot BO'' \cdot CO = rr'r''/r'r''r = 1$. Hence by Menelaus's Theorem, ABC are in a straight line.

Similarly solved by J. H. Packham and A. Pelletier (3). The third solution by Pelletier is interesting;

II. Let us consider the circles OO′O″ as great circles of spheres; then the two tangent planes inclosing the spheres contain the points A, B, C; hence these points are on the intersection of the two planes which is a line.

III. As the Theorem of Menelaus is found in few elementary geometries, its statement and proof is given here:

Every straight line (ABC) cutting the sides of a triangle (OO′O″), produced if necessary, determines upon the sides six segments such that the product of three non-consecutive segments equals the product of the other three.

Draw O″D parallel to OO′, D being on ABC. From the similar triangles we get

$AO/DO'' = CO/CO''$ and $BO'/BO'' = AO'/DO''$.

Multiplication of these two equations gives the desired result.

To prove the converse let AB produced cut OO″ in a point E; then prove OE = OC.

PROBLEMS FOR SOLUTION.

671. *Proposed by Emma H. Carroll, Phila. High School for Girls.*

Without the use of trigonometric relations prove: the distance on a side of a triangle from a vertex to the point of tangency of the inscribed circle equals one-half the perimeter minus the side opposite the vertex.

672. *Dissection Problem proposed by Norman Anning, Ann Arbor, Mich.*

An equilateral triangle AFG is described outward on the side AF of the regular hexagon ABCDEF. It is required to cut the figure so formed into three parts that will make an equilateral triangle.

673. *Proposed by the Editor.*

The following problem is a "Sam Lloyd" puzzle taken from a Chicago newspaper. Its wording could be improved as it does not state who is the oldest but the solution will reveal it. Although the paper said that no correct solution was received, algebra will help to solve it.

A father settled an annuity upon his three children, the same to be divided each year in the same proportion as their ages. At the first division the oldest was entitled to one-half of the entire amount. When the sixth payment was due, Martha received one dollar less than she did the first year, Phoebe one-seventh less than she first got, while John's share was twice as much as he received the first year. What is the amount of the annuity?

674. *Proposed by Herbert C. Whitaker, Philadelphia, Pa.*

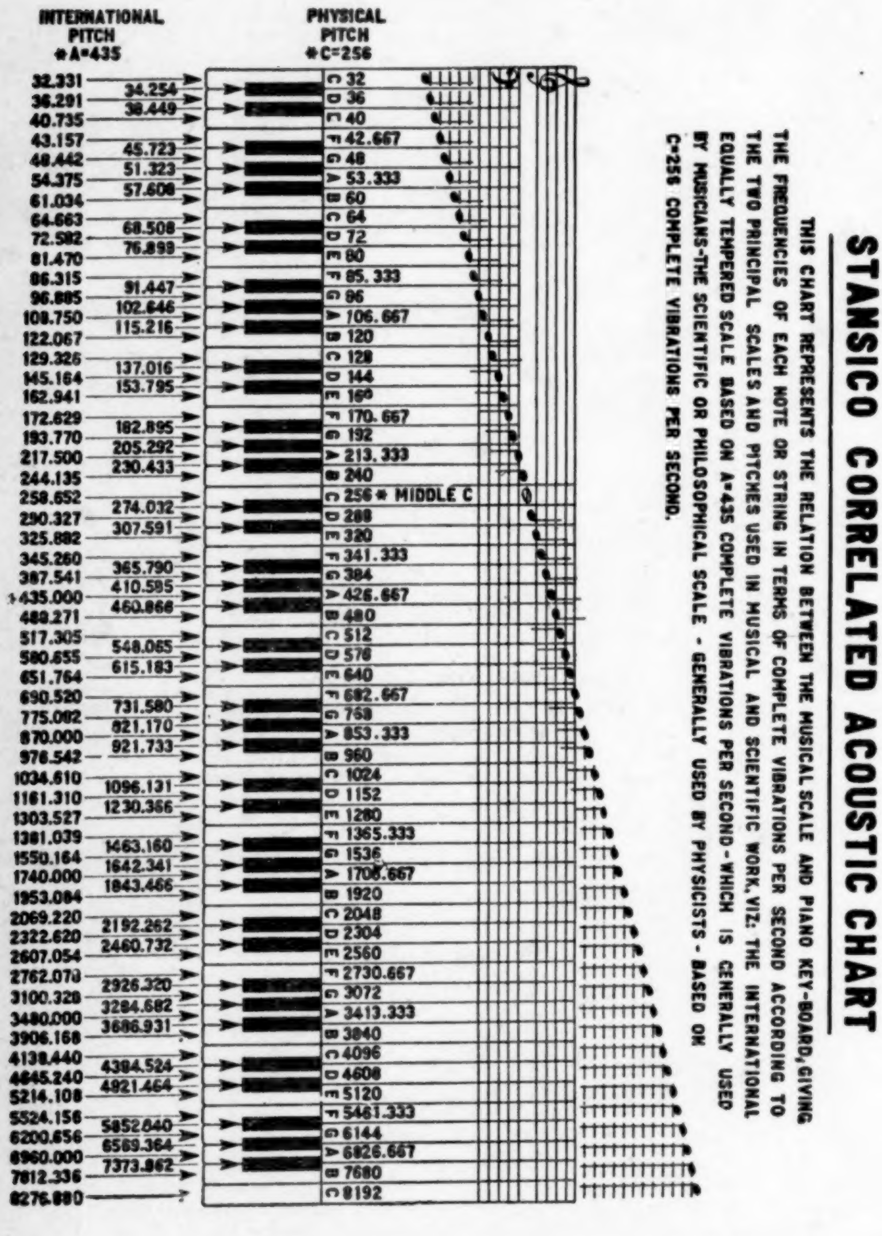
From a cask of wine holding 10 gallons, a dishonest servant draws off a gallon each day for 20 days filling the cask each time with water. But fearing detection, he again draws off a gallon each day for 20 days, filling the cask each time with wine. How much water remained?

675. *For Undergraduates. See announcement in October issue.*

Proposed by Norman Anning, Ann Arbor, Mich.

G is the obtuse angle of a triangle whose sides are 7, 15, 20. H is the obtuse angle of a triangle whose sides are 5, 5, 8. Prove that

$$2G + H = 360°.$$



"A sample copy of the above chart will be sent without charge by addressing the Standard Scientific Company, 147 Waverly place, New York."

INDUSTRIAL ART SCHOOLS.

Establishment of industrial art schools in the United States, to meet the demand for designers and craftsmen, is urged by the American Institute of Architects.

Over half a million dollars is on deposit in one of the San Francisco banks to the credit of 20,788 school children. These school savings are in addition to large investments by the children in thrift stamps and war savings stamps.

Approximately 20 per cent of all children in the schools are in need of corrective treatment for eye defects, according to a bulletin on "The Eyesight of School Children," soon to be issued by the U. S. Bureau of Education.

A one story school building with as many as 48 rooms in a well-populated city and suburban section is possible under a plan adopted in Cuyahoga County, Ohio. This county now has four large school buildings of the one-story type, with from 5 to 10 acres of ground for each building.

More than a thousand men and women of foreign birth were enrolled in the Scranton, Pa., public evening and afternoon schools for non-English speaking men and women during the past year. Twenty-two nationalities were represented in the citizenship graduating class of 132 persons recently, according to reports received by the U. S. Bureau of Education.

"Sea gardening" is a feature of the school garden work among the Moros, in the Sulu group of the Philippine Islands, according to a report of the Commissioner of Education. Because the islands inhabited by these people, sea rovers for centuries, offered few facilities for cultivation of the ordinary crops, the schools established "sea gardens" in which attention is given to the culture of marketable sea products, especially certain kinds of sponges.

CLASSROOM SAYINGS.

Question: Tell how the mercury thermometer is made, and compare the centigrade scale with the Fahrenheit scale.

Answer: They put it in a real hot boiler and seal it. Then they put in a real cold place and freeze it. Ice is good. Then they let it stand for five years, and after this they put a scale on it. Fahrenheit is a smaller scale than the centigrade.

A Fundamental tone is a tone produced when the string does not vibrate.

A virtual image is one that cannot be seen in the dark. A real image can.

Refraction of light is inversely proportional to the perpendicular.

From General Science Pupils.

A draft may be caused in a chimney sometimes because the chimney is too short and sometimes the wind may be blowing directly on that chimney.

Cause of draft in a chimney—not enough air on the inside to withstand that on the outside.

Relative humidity means moisture in the air in relation to the body.

The cold air of the draft gets into the pores of the skin and we catch cold.

A barometer is an instrument that measures the pressure of the atmosphere by degrees.

I would predict a frost when the dew freezes.

The words ampere, ohm, volt, watt, suggest to my mind a course in electricity.

Teachers: Send to the Editor samples of your very interesting answers.

DIMENSIONS AND AREA OF THE UNITED STATES.

The gross area of the United States is 3,026,789 square miles. The land area amounts to 2,973,774 square miles, and the water area—exclusive of the area in the Great Lakes, the Atlantic, the Pacific, and the Gulf of Mexico within the three-mile limit—amounts to 53,015 square miles. These and other data determined or compiled by the United States Geological Survey, Department of the Interior, to show the limits of the continental United States contain some interesting facts.

The southern most point of the mainland is Cape Sable, Fla., which is in latitude 25° 07′ and longitude 81° 05′. The extreme southern point of Texas is in latitude 25° 50′, and longitude 97° 24′. Cape Sable is therefore 49 miles farther south than the most southern point in Texas.

A small detached land area of northern Minnesota at longitude 95° 09′ extends northward to latitude 49° 23′.

The easternmost point of the United States is West Quoddy Head, near Eastport, Maine, in longitude 66° 57′ and latitude 44° 49′; the westernmost point is Cape Alva, Wash., in latitude 48° 10′, which extends into the Pacific Ocean to longitude 124° 45′.

From the southernmost point in Texas due north to the forty-ninth parallel, the boundary between the United States and Canada, the distance is 1,598 miles. From West Quoddy Head due west to the Pacific Ocean the distance is 2,807 miles. The shortest distance from the Atlantic to the Pacific across the United States is between points near Charleston, S. C., and San Diego, Calif., and is 2,152 miles.

The length of the Canadian boundary line from the Atlantic to the Pacific is 3,898 miles. The length of the Mexican boundary from the Gulf to the Pacific is 1,744 miles. The length of the Atlantic coast line is 5,560 miles and that of the Pacific coast line is 2,730 miles. The Gulf of Mexico borders the United States for 3,640 miles.

Nearly all maps of the United States show the parallels of latitude as curved lines and are likely to lead the ordinary observer to believe that certain eastern or western States are farther north than some of the central states that are actually in the same latitude. For this reason, one who is asked which extends farther south, Florida or Texas, is very likely to say "Texas," but, as stated, the mainland of Florida is nearly 50 miles farther south than the southernmost point in Texas. For the same reason, when we consider the geographic positions of countries south of the United States we find that errors are likely to be made in estimating position or extent in longitude. Few realize that the island of Cuba, for example, if transposed directly north would extend from New York City to Indiana, or that Havana is farther west than Cleveland, Ohio, or that the Panama Canal is due south of Pittsburgh, Pa., or that Nome, Alaska, is farther west than Hawaii.

ANIMAL WEATHER PROPHETS.

"Mere superstition," so the weather authorities say, are many of the long-distance weather predictions based on the conduct of animals. No one, so far as we know, has compiled a record of these so-called omens, but their number is multiple. They are based on a belief that animals are able to tell months in advance, for example, the character of the coming winter. If hunters bring a story to the effect that squirrels have made heavy stores of nuts, it is taken to mean that a severe winter impends. If early caught fur-bearing animals have a heavy, thick coat, that is another sign of a severe winter, or a thin coat, the contrary. If bird migrations are delayed after the usual date of the southward flight, a sign is seen of an open winter. Numerous other beliefs based on fancied ability of animals

to foresee weather conditions months ahead, and base their preparations on them, have wide currency. Sometimes signs are taken from the vegetable world, as for example, the past fall in the Middle West. Corn husks, it was related, were much heavier than usual—that meant a hard winter.

The reasoning, such as it is, in many of these weather signs, is apparent on the surface. In the case of others it isn't, as with the most famous and well-known of them all—the groundhog sign. If Mister Woodchuck on Candlemas day—February 2—sees his shadow, issuing experimentally from his den, then "winter will have another flight." Otherwise an early spring impends.

Observation over a part of a single lifetime would demonstrate most of these weather signs as unreliable, yet they cling on, especially in country districts. It is possible that they do so, in part, because they shadow into animal signs of a different class which really are dependable. From the conduct of animals, accurate weather predictions can, within certain limits, be made.

This dependable class of animal weather signs is uniformly short distance as to prophecy—no longer than the daily newspaper weather forecast. They occur because animals are more sensitive to atmospheric changes than human beings, and sense an approaching weather change hours before it is apparent to man. . . .

One animal barometer in this class, much observed east and west during the summer season, is the swallow. The swallow is insectivorous to the -*nth* degree. Other than insects hardly pass its bill from one season's end to another, and it captures this food on the wing. Thus it happens that as a weather forecaster the swallow on thousands of farms is always ready with an answer.

Swallows flying high indicate fair weather. Swallows flying low presage a storm. The explanation of these "signs" is simple. The relative level at which swallows fly is determined by the whereabouts of insects. The lighter the atmosphere, as in the case of fair weather or clearing weather, the higher will insects be found, while an oncoming storm, presaged by growing density, forces them to levels near the ground, where the swallows will be noticed in pursuit of them.—*Scientific American.*

PLANT PROTECTION INSTITUTE.

With the advice and assistance of the National Research Council, a cooperative body of scientific experts on injurious insects and plant diseases and of manufacturers of insecticides, fungicides and general chemicals and apparatus used in fighting the enemies of field and orchard crops, has just been organized under the name of the Plant Protection Institute. The purpose of the institute is to promote the general welfare by supporting and directing scientific research on the pests of crops, shade trees and ornamental plants, and on the methods of their control, and by furthering cooperation between the scientific investigators and the manufacturers of chemicals and appliances, especially for the sake of effecting standardization and economy in the production and use of the means of fighting pests. Also it expects to aid in the dissemination of scientifically correct information regarding the control of injurious insects and plant diseases.

Much excellent work along this line is now being done by government and state organizations, but a further advance can be made by introducing a wider coordination and cooperation of the efforts of both the scientific men and the manufacturers of control devices. It is in this general direction of cooperative work that the Plant Protection Institute expects to be most active.

INDUSTRIAL RESEARCH LABORATORIES IN AMERICA.

A bulletin just issued by the National Research Council lists more than three hundred laboratories maintained by industrial concerns in America, in which fundamental scientific research is carried on. The bulletin gives a brief account of the personnel, special equipment and particular kind of research carried on in each of the laboratories listed.

Industrial research laboratories have increased notably in number and activity, both in America and Great Britain, since the beginning of the war, because of the lesson vividly taught by the war emergency. It was only by a swift development of scientific processes that the Allies and America were able to put themselves in a position first to withstand and then to win a victory over Germany's science—backed armies and submarines. It is only by a similar and further development that America and the Allies can win over Germany in the economic war-after-the-war, now being silently but vigorously waged.

LAKE TAHOE HAS SHRUNKEN.

Lake Tahoe, in California, is often said to occupy an old volcanic crater. This is not a fact. It is true that the region about the lake shows evidence of volcanic activity of various kinds and that the water has at times probably been dammed by outpourings of lava, but the lake itself lies in a structural depression—a dropped block of the earth's crust.

The prehistoric Lake Tahoe was larger and deeper than the present lake according to the United States Geological Survey, Department of the Interior. During the Neocene epoch and the earlier part of the Pleistocene epoch its water stood much higher than now but in its overflow it has since cut through the lava dams that maintained it at that height. Distinct beaches that mark the former higher levels of the lake stand about 100 feet above its present surface but the water doubtless once stood at even greater heights. At Tahoe City the most distinct of these old beaches is a terrance that stands 35 to 40 feet above the level of the lake. It is on this ancient beach that Tahoe Tavern is built.

MAPS OF SUMMER RESORTS IN SOUTHWESTERN MAINE AND SOUTHEASTERN NEW HAMPSHIRE.

Summer vistiors to the famous resorts along the southwestern coast of Maine and the neighboring part of New Hampshire will welcome two new topographic maps just issued by the United States Geological Survey, Department Interior, covering areas in the vicinity of York and Portsmouth. The York map shows the coast line from Ogunquit Me. southward to Rye North Beach, N. H., also the towns of York, Kittery and part of South Berwick, Me. and the eastern part of Rye, N. H. At the southern extremity are shown the Isles of Shoals. The Portsmouth map, which will be of more service to those interested in the neighboring interior country as well as the coast, includes the area shown on the York map, also the cities of Portsmouth and Dover and the neighboring towns as far northwest as Rochester and as far southwest as Exeter.

The topography is shown in brown contour lines, and a special feature is the depiction of the relief of the sea bottom by blue contour lines which give striking evidence of coastal submergence. Many typical features of glaciation are well illustrated, and one of the most prominent is the Monadnock mountain Agamenticus, in York, which rises to an altitude of nearly 700 feet and is a prominent landmark visible for miles at sea and on clear days even from Cape Ann, Mass., about 40 miles away.

Copies of the York and Portsmouth maps may be purchased for 10 and 20 cents each, respectively, from the Director, United States Geological Survey, Washington, D. C.

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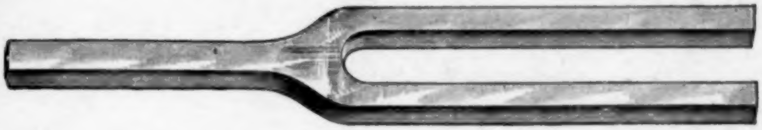

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The text is arranged according to the phases of home economics and correlates perfectly with home economic courses, which makes arithmetic much more attractive to the girl because the problems dealt with are those with which she comes in contact in everyday life. The pedagogy is modern and sound; although in a sense a review arithmetic, the book presents its topics in the simplest and most thorough manner. It is possible to divide the book into the parts of arithmetic lying within certain definite household fields—see table of contents.

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PRODUCTION OF ASPHALT IN THE UNITED STATES.

A preliminary estimate of the production and sales of asphalt and native bitumens and allied substances in the United States in 1919 has just been made public by the United States Geological Survey, Department of the Interior. The asphalt produced from domestic petroleum amounted to 600,000 short tons, valued at $9,000,000 an apparent increase over 1918 of 72,425 tons and of $1,564,796 respectively. The asphalt produced from Mexican petroleum amounted to 672,000 short tons, valued at $7,917,000 an increase from 1918 of 21,756 tons in quantity and a decrease of $1,407,020 in value. About 115,000 short tons of native bitumens and allied substances valued at $1,000,000 was produced in 1919, an apparent increase over 1918 of 54,966 tons and of $219 192.

VARIETY IS THE SPICE OF LABORATORY WORK

By C. C. Leeson,

State Teachers College, Maryville, Mo.

There is abundant opportunity for a wide variety of activities in the laboratory work of General Biology, Science or Nature Study. To make the most of this variety will give training in methods of work as well as in scientific facts and principles. Not infrequently anatomical work and diagramatic and written records usurp most of the time. Often lower types only are studied and the student never gets as far as the more practical phases of birds and mammals. My own experience as a college student gave me no greater variety than the above mentioned.

The purpose of this article is to cite and give representative problems under fifteen different types of laboratory work. The teacher of science will do well to outline the laboratory problems of a given subject or term so as to include as many of these types as possible.

I. The illustrated lecture.—Students make small charts, 4x4 inches, or reflectoscope pictures on such topics as—bird attraction, insect control, rural sanitation, weeds, ornamental planting, etc. These are given as lectures with genuine value and interest.

2. Collection making.—Each student chooses a different topic and near the end of the term displays and explains all he knows about each specimen. Some good collections are: tree barks, buds, fruits, leaves, vines, poisonous and medicinal weeds, insect pollinated flowers, protective devices, nature photos, butterflies, harmful insects, etc.

3. Game day.—Nature conundrums, bird picture games, naming contests on numbered pictures and objects, dramatic presentations, nature games and contests of the boy scouts and camp-fire girls. Get ideas from the students and make this a real educative holiday.

4. Continued project.—Keep an aquarium stocked, window box care, starting young plants, potato planting experiments, flower culture, ornamental plan carried out, rearing caterpillars and insects, studies in animal behavior, with a migration record, etc. Students may work in pairs or groups with a chosen leader.

5. Construction.—This should include not only the making of a device but the plan drawing, practical use and correlated work of other subjects. A selection from which to choose are: fly trap, nesting boxes, aquarium rearing cage, collecting outfit for insects, demonstration ant nest, mechanical toys, etc.

6. Survey.—A plot of ground may be mapped with its actual and probable plant and animal distribution, bird nests, contour; or a health survey, a sanitary survey of dairies, stores, etc.; a survey of ornamental plantings, poultry varieties, pets and breeds of domestic animals, mosquito and fly breeding places.

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7. Field trip.—To identify birds, trees, weeds, wild flowers, mosses and ferns, to observe ornamental plans and plants, adaptive structure and habits of plants and animals, plant distribution, to collect laboratory or museum material.

8. Demonstration.—Some known principle or fact is verified in the laboratory, such as transpiration, photosynthesis, osmosis, phototropism, diffusion, etc.

9. Experiment.—An unknown reaction or quantitative result is determined, such as: amount of transpiration, rapidity of growth, optimum temperature for growth, relation of oxygen to germination, etc.

10. Dissection and anatomical study. This type of work is often overdone, and laboratory directions are often so explicit as to leave nothing but thoughtless routine for the student.

11. Microscopic observation.—Micro-organisms, cells, tissues, staining effects, mitosis, etc., with some microscopic technique.

12. Tabulated studies of collections.—The various collections that students may build up in a laboratory may be analyzed and recorded in columns such as for seed dispersal; name, by what carried, carrying device, sketch.

13. Cooperative project.—Planning and planting home grounds or school grounds, flower beds, garden plots, making a card catalogue of library topics, or laboratory exercises, collecting a school herbarium, making a loose leaf bird-house book, giving a dramatic presentation, etc.

14. Illustrating facts and stories by graphs or free hand drawings, diagrams, models, pantomine, etc. The teacher may give statistics and ask for graphical representation, or read a story which is to be pictured by free hand sketch or vice versa.

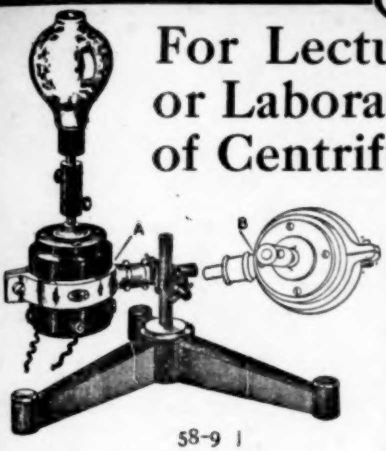
15. Exhibition day.—The best displayable work of the term is selected and arranged for public observation in corridor or display cabinet.

NOTES AND NEWS CONCERNING THE WORK OF THE NATIONAL COMMITTEE ON MATHEMATICAL PROBLEMS.

(September 15, 1920.)

The National Committee on Mathematical Requirements held a meeting at Lake Delavan, Wisconsin, on September 2, 3, and 4, at which a number of reports were discussed and adopted. A report on The Revision of College Entrance Requirements received the greatest amount of discussion. It is hoped that this report may be released for publication early in October. It includes a general discussion of the present problems connected with college entrance requirements in mathematics, a report of an investigation recently made by the National Committee concerning the values of the various topics in elementary algebra as preparation for the elementary college courses in other subjects and a suggested revision of the definitions of entrance units in elementary algebra and plane geometry. In connection with the suggested requirements in plane geometry a list of fundamental propositions and constructions is attached. This list includes the proposition which may be assumed without proof or given informal treatment, a list of the most fundamental theorems and constructions from which it is intended that questions on entrance examination papers other than originals be chosen, and a list of subsidiary theorems. It is proposed to prepare a mimeographed edition of this list of propositions and constructions at the earliest possible moment, for the benefit of such teachers as may desire to make use of it in connection with their classes during the coming year. A copy will be sent to any person interested upon application to the Chairman of the Committee, J. W. Young, Hanover, New Hampshire.

For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .



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A preliminary draft on Mathematics in Experimental Schools was discussed at this meeting. Raleigh Schorling of the Committee has spent over a year collecting material for this report. It is hoped that it will be ready for publication early next spring. The report will be an extensive one and will describe in detail the work actually done in mathematics in experimental schools throughout the country.

Miss Vevia Blair of the committee presented her report on the Present Status of Disciplinary Values in Education. It is expected that this report also will be released for publication in October. It gives a critical review of the complete literature concerning the experimental work on the transfer of training as well as an evaluation of this literature terminating in the formulation of certain propositions concerning disciplinary values which appear justified by the experimental work. A particularly valuable feature of the report would seem to lie in the fact that a large majority of the most prominent psychologists in the country appear to be ready to subscribe to the propositions formulated.

Professor E. R. Hedrick presented a report which he prepared at the request of the National Committee on "The Function Concept in Secondary School Mathematics." This report also will be published in the near future and is intended ultimately to form a part of the final report of the committee on the reorganization of the first courses in Secondary School Mathematics. A preliminary report on this subject was published for the committee by the U. S. Bureau of Education last February as Secondary School Circular No. 5.

A preliminary report on Junior High School Mathematics is in the press of the U. S. Bureau of Education and should be ready for distribution early in October. The National Committee desires the assistance of its cooperating organizations, which now number about 70, in the revision of this preliminary report. Comments, suggestions and criticisms should be sent to the chairman of the committee not later than January 1, in view of the fact that the committee expects to take up the formulation of its final report on this subject immediately after this date.

A subcommittee under the chairmanship of Professor C. N. Moore is preparing a report on "Elective Courses in Mathematics in Secondary Schools." A committee under the chairmanship of Professor David Eugene Smith is preparing a report on "The Standardization of Terminology and Symbolism," and Professor R. C. Archibald is preparing one on "The Training of Teachers." It is expected that all three of these reports will be presented for the consideration of the National Committee in October.

The work of the National Committee and its recommendations were discussed in teachers classes at the summer sessions of colleges, universities and normal schools throughout the country. Addresses on the work of the committee were given as follows: By Mr. Raleigh Schorling at Harvard University, by Professor E. R. Hedrick at the Universities of Texas and of Oklahoma, and by J. A. Foberg at the Universities of Iowa and Minnesota.

Present indications point to the fact that the work of the National Committee will have a prominent place on the programs of most teachers organizations throughout the country during the coming year. The National Committee stands ready as before to help in every possible way in the preparation of such programs and will be glad to furnish material for discussion.

It will also be pleased to furnish speakers for such meetings to the extent of its ability.

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EFFECT OF A FLORIDA FREEZE ON INSECTS.

The disastrous Florida freeze of February 2-4, 1917, which killed or practically defoliated the citrus trees in Putnam, Volusia, and Marion Counties, and parts of Lake and Orange Counties, and heavily damaged trees in other sections of the State, was of considerable importance in "reducing the numbers of injurious pests which infested the trees." In the section where temperatures as low as 15° or 20° F. occurred the freeze or the falling and drying of the leaves nearly exterminated the rust mite and varieties of white fly and scale insects. Few adult specimen of the various species survived except on fired or otherwise protected groves or individual trees. Of the red scale it is believed that perhaps not more than one in 100,000 remained alive. The almost complete extermination of this species by the freeze and its reproduction to billions in six months is a most remarkable biological fact. In some instances there was no need of the usual early spraying yet, singularly enough, in most cases the normal number of insects appeared in the following summer or fall. So, as a rule, the setback in insect life, however great even over the area of maximum freeze, was only temporary.—*W. E. H.* in *Monthly Weather Review.*

THE TEACHING OF GEOGRAPHY AND THE WORLD WAR.

By H. E. Branom,

Harris Teachers College, St. Louis.

At the outbreak of the World War the emphasis in the teaching of geography had shifted from locational and descriptive to interpretative and relational geography. Facts were still needed, and memory work was held in high esteem, but an attempt was made to interpret the interacting relations between man and his physical environment. The standard topical outline, in many instances, was retained, but each of the topics, as location, area, topography, climate, life forms, and human activities, was considered from the standpoint of its influence on man and his activities.

During the World War, every member of the social group, including the children, led an intensified intellectual existence. Even the children were asked to assist in numerous ways. They eagerly responded, because they had an opportunity to engage in worth-while, purposeful activity, the product of which was helpful in strengthening our army and navy in overcoming our aggressive enemies. The spontaneous, hearty response indicated the importance of confronting the pupils with situations which make a strong appeal.

The study of home geography received an additional impetus. In each community factories engaged in manufacturing activities that directly contributed to the winning of the war were run at full capacity. Factories engaged in the production of "non-essentials" were shut down or their output was restricted. This expansion and contraction of industries affected directly the community life and stimulated the people, through the interest aroused, to attempt to interpret the local economic activities. The shortage of products, as sugar and wheat flour, and the dependence of the local area on far away lands for products and for markets, aroused an interest, with the community as a point of departure, in the world as a whole. The teacher, recognizing the value of using the social interests in her geography work, placed increasing emphasis on home geography, not only because of its intrinsic value—but because of its usefulness in the interpretation of the far away.

The War strongly suggested the desirability of approaching the study of geography from the social viewpoint. The War fundamentally arose out of a difference in ideals among the groups of people. The attention

of the people was first drawn to the various disagreements among the groups. An understanding of the different viewpoints, however, required a knowledge of the varying physical backgrounds. In the great clash of nations, inequalities in the distribution of valuable plants, animals, minerals, and transportation facilities were significant in determining the outcome. In attempts to socialize the work teachers had tended to forget the physical background. The dependence of nature's resources emphasized the need of securing a social reorganization of the course of study on a physical basis. The geography problems arose out of the social situation and required the physical factors for their interpretation.

The interest aroused in various parts of the earth created a heavy demand for geographical books, magazines, maps and globes. This need was met in part by making use of the dust-covered materials of the schools, in part, by the purchase of new equipment. Better facilities for the teaching of the subject and a more intelligent use of equipment helped to popularize geography.

With the removal of the unusual stimulus afforded by the World War, teachers have sought a satisfactory substitute, by appealing to the child's interests and experiences through current events and the use of local industries and physical features. It is no longer held that the best teaching can be accomplished through a standardized outline. Each area is studied from the standpoint of the more important problems and the various parts of the old topical outline are emphasized according to their relative values in helping to solve the problems.

The project-problem is being emphasized more and more. Several large school systems have attempted to organize all of their regional geography on this basis. An introductory discussion, appealing to the child's interests and experiences, may arouse in the minds of the class a worth-while problem. Materials bearing on the problem are secured, and through their interpretation and evaluation the problem is solved.

The problem, Should Great Britain encourage the establishment of an Irish Republic? may be thrust before the class, but, preferably, a brief discussion of the Irish situation related to current events may cause the problem to arise. After the problem is raised and concisely stated, the economic, social, religious, and strategic factors having a bearing on the problem will be discussed in the light of the physical background. After a thorough discussion the problem is solved or the material is summarized.

In directing the discussion of problems considerable ability is required, for it scarcely can be expected that any representative group, even among children, will come to a unanimous agreement concerning all social problems. We are coming to believe that vital problems should be discussed and we are coming to judge a teacher, in part, by the skill she shows in developing all parts of a problem, in securing a free and easy discussion, in getting the children, although perhaps disagreeing, to respect the opinions of each other, in teaching children how conscientiously to discuss problems over which there may be serious disagreement and yet to continue to dwell together in brotherly love.

TREMENDOUS SNOWSTORM IN PALESTINE, FEBRUARY 9-11, 1920.

By Otis A. Glazebrook,
American Consul.

On the afternoon of February 9, 1920, a maid of the consulate ran into the house gleefully showing a handful of snow which she had pressed into a snowball. It was the first snow she had ever seen. As the weather had been constantly inclement since the middle of November, 1919, I supposed

that this was but a snow flurry ending the former rains, as over 27 inches of rain had already fallen, this quantity being far above the average at this time of the year. In 36 hours afterwards, however, Jerusalem and the surrounding country for miles had been mantled by a snowfall which averaged on the level 40 inches, with drifts in many places reaching a height of 10 feet.

In the memory of the inhabitants of Jerusalem this was the greatest snowfall and the people were absolutely appalled by it. I recall the great blizzard of 1888 and remember many other heavy falls of snow in the United States, but none compared in possibilities of danger to this one. The locust visitation of 1915 falls into insignificance as compared with it. The people of this country being unused to such a phenomenon were totally unprepared to contend with it. There were no snow plows or even snow shovels, and if there had been the population would not have known how to handle them. All communication within the snow limit was interrupted, and the falling of the telegraph wires, the blocking of the railroad and all thoroughfares cut us off entirely from the outside world. Every store was closed. The Felahin could not bring their products to the markets. There was a shortage of bread and a dearth of wood and kerosene, and starving and freezing faced the people. Fortunately, there is a battalion of Yorkshire troops garrisoning the city. This battalion saved the situation. At once over 700 men were at work with shovels opening the roads and streets in the city and digging out the buried population. When the stores were opened the spirit of profiteering which was already remorselessly abroad in this community—causing the prices of all necessaries, not to speak of luxuries, to increase from five to ten times their former value, having made Jerusalem in the past year possibly the most expensive place in the world, the cost of living being twice as high as in Egypt and in Syria—knew no restraint. In consequence, mob violence was imminent and the military governor was compelled to strenuously reduce the price of bread and other food commodities.

At least 40 houses in Jersualem were crushed in by the weight of the snow, but, strange to say, the casualty list is comparatively short. When at last unfettered, the inhabitants in general proved equal to the occasion by sharing their own provisions with the poor and improvident. Conditions are now normal, the telegraph and railroad lines being in operation, stores opened, and native products coming into the market. The snow has rapidly disappeared, and except for the continued high winds and unusually cold weather one would not believe that the city had just raised itself from the dead. This blizzard will go down to history as one of the most remarkable and dangerous occurrences in the history of the Holy City, a city by no means unacquainted with extraordinary incidents.—*Monthly Weather Review.*

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NOTES AND NEWS REGARDING THE WORK OF THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

The National Committee on Mathematical Requirements held a meeting in Chicago on April 23d and 24th, 1920. The principal topic discussed at this meeting was the preliminary report on "Junior High School Mathematics" prepared for the Committee by Mr. J. A. Foberg. After detailed discussion and some amendment and revision, the report was adopted by the Committee and its publication as a preliminary report authorized. It has been submitted to the U. S. Bureau of Education for publication as one of its secondary school circulars.

This report considers briefly the history of the Junior High School Movement, its purposes and organization; it proposes certain general principles to govern the organization of work in mathematics in the junior high school and considers in some detail the topics to be included. The Committee feels that much experimentation must still precede any attempt at standardization of the junior high school curriculum in mathematics. Its recommendations are intended to form the basis of study, discussion and class room experiment. To this end the cooperation of teachers and supervisors is earnestly solicited. The National Committee hopes to act as a clearing house for constructive criticism based on actual class room experience.

The following resolution was adopted:

RESOLVED: That the National Committee on Mathematical Requirements approves the junior high school form of organization and urges its general adoption in the conviction that it will secure greater efficiency in the teaching of mathematics.

Reports of progress were made by subcommittees on The Training of Teachers, Experimental Schools and Courses, Disciplinary Values and Transfer of Training, Elective Courses in Mathematics for High Schools, and Mental Tests. It is expected that preliminary reports on all of these topics will be ready for consideration by the Committee at its next meeting on September 2nd, 3rd and 4th. The attention of experimental schools throughout the country is called to the report on this subject being prepared for the Committee by Mr. Raleigh Schorling of the Lincoln School, New York City. Any experimental schools or schools giving experimental courses in mathematics who desire to be represented in this report should communicate with Mr. Schorling without delay, if they have not already done so. A subcommittee on the Standardization of Terminology and Symbolism with Professor D. E. Smith as Chairman and a subcommittee on Junior College Mathematics with Mr. A. C. Olney as Chairman were appointed. J. W. Young, Raleigh Schorling, and W. F. Downey were authorized to take steps to initiate investigations into the mathematical elements entering into various industries, professions, vocations, etc.

A budget for the coming year based on the recent appropriation of the General Education Board of $25,000 for the use of the Committee in completing its work was adopted. It is hoped that the increase in the item allowed for traveling expenses in this budget will make it possible for representatives of the Committee to reach educational meetings in all sections of the country where such representatives are desired to discuss the various reports of the Committee. Nearly 70 organizations are at present actively cooperating with the Committee and it is hoped that many others will communicate with the Chairman in the interest of furthering the nation-wide study and discussion which is already under way. J. W. Young, 24 Musgrove Building, Hanover, New Hampshire, and J. A. Foberg, 3829 North Tripp Avenue, Chicago, Illinois, were reelected Chairman and Vice-Chairman, respectively, of the Committee for the ensuing year.

"THE INDIVIDUAL AND THE CURRICULUM: EXPERIMENTS IN ADAPTATION." This is the title of the sixth volume of the *Francis W. Parker School Studies in Education* (a series of booklets published by the Faculty, and formerly entitled *Year Books*). Surely no subject is more vital to thoughtful teachers of today. Although they may believe with heart and soul that real education means the teaching of individual human beings rather than subject matter, they are nevertheless thwarted in the practice of this faith at every turn by the required cast-iron courses of study designed for a wholesale, machine-made "human" product.

Miss Jennie Hall's article on the trial of the individual project method in a seventh grade class shows what can be done in a school where freedom for experimentation exists, to develop through the daily work, the special interests and distinct personality of each child. The idea is not given, as too frequently happens in educational publications, in its theoretical stage. It is the account of a year of actual practice. The daily schedule, the home study, the teacher's plan for estimating the values of the work for each child, are made clear by illustrative charts as well as by thorough explanation.

Much of the average child's power of intellectual growth is wasted because the subject matter offered him for the exercise of this power does not command his sympathy and willing effort. The individual project method is the freest solution of this difficulty. But there are other ways of preventing this waste of energy in irksome and unproductive study. Experiments and methods within the scope of the more usual class room work of any school are sketched in a group of articles entitled *Social Interest in the Class Room.* These articles contain suggestions—in the form of records of actual work done—for bringing almost every study in the average school course into definite relation with the compelling interests of the time or of the individual child.

Four very different studies of Lincoln, made by four different eighth grade classes, are given in the form of verbatim reports of the Lincoln Exercises before the school assembly, programs which culminated the class study each year. Practical interests of today in the high school science work, the development of the correspondence scheme in modern language study, the relinquishing of all textbook arrangements of the civics course in order to make it bring to the child certain vivid experiences—these are typical examples of the contents of this section. It is followed by a very concrete and graphic report of a group of community adventures in the school—a paper-saving campaign, a war-service bankbook, a postage-saving device, etc.—which point out the great wastefulness of the average American, and which suggest ways of making thrift not only a habit, but also the basis of genuinely educative class room work.

The next group of articles shows the articulation of the art and eurythmics work with other subjects of the child's study. But more than this, it indicates at every point the enrichment of the entire conscious life of the child through adequate opportunity for aesthetic experiences of all sorts, experiences which use every faculty, which make for many new contacts, and which leave the child free to express what is his own. The clear explanation of the Jaques-Dalcroze method of eurythmics as taught in the Parker School by one of his pupils will be helpful to schools contemplating the introduction of rhythmic gymnastics into their course of study.

While less focussed upon one phase of the study than previous numbers of the *Studies in Education*, this volume is especially valuable in giving a cross-section of the school life as it is influenced by one of the underlying principles of the school.

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ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for October; *Lancaster, Pa.*: $4.00 *per 1 year*, 50 *cents a copy:* "The Average Reading Vocabulary; An Application of Bayes's Theorem," Warren Weaver; "A Graphical Aid in the Study of Functions of a Complex Variable," Norman Miller; "Modular Geometry," A. A. Bennett; Questions and Discussions: "Note on the solution of fractional equations," C. A. Noble; "Determination of an angle of a right triangle without tables," R. A. Johnson.

Geographical Review, for July; *Broadway at* 156*th Street, New York City:* $5.00 *per year*, 50 *cents a copy:* "Cape Cod and the Old Colony," Albert P. Brigham (1 map); "The San Blas Indians of Panama," S. P. Verner (5 photos); "New Orleans in Early Days," Edna F. Campbell; "Wandering Storms," Alexander McAdie (3 maps).

National Geographic Magazine, for October; *Washington, D. C.*: $3.50 *per year*, 35 *cents a copy:* "Nepal: A Little-Known Kingdom," 33 illustrations, John C. White; "Human Emotions Recorded by Photography," 16 illustrations, Ralph A. Graves; "Tahiti: A Playground of Nature,"

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15 illustrations, Paul Gooding; "The Making of a Japanese Newspaper," 5 illustrations, Thomas E. Green.

Physical Review, for September; *Ithaca, N. Y.: $7.00 per year, 75 cents a copy:* "Charcoal Activation," H. Horton Sheldon; "The Effect of Temperature upon the Transmission of Infra-Red Radiation through Various Glasses," George Rosengarten; "The Theory of Linear-Sinoidal Oscillations," Henry G. Cordes; "The K-Characteristic Absorption Frequencies for the Chemical Elements Magnesium to Chromium," Hugo Fricke; "The Audion Oscillator," R. A. Heising; "Application of Electric Currents in the Bunsen Flame," C. W. Heaps.

Popular Astronomy, for October; *Northfield, Minn.: $4.00 per year:* "Twenty-Fourth Meeting of the American Astronomical Society," Plate XXI; "The Orthographic Projection of a Sphere," William H. Pickering; "The Design and Construction of a Small Observatory," J. E. G. Yalden; "An Elementary View of Diffraction as Applied to Photographic Photometry" (Concluded), Alice H. Farnsworth; "The First Attempt to Adopt the Gregorian Calendar in England," Roscoe Lamont; "Some Recollections of John A. Brashear," H. B. Rumrill; "First Study of Heavenly Bodies, Mary E. Byrd.

School Review, for September; *University of Chicago Press: $2.50 per year, 30 cents a copy:* "Classification of Pupils in Ability Groups," James M. Glass; "Training for Citizenship through Practice," Frank G. Pickell; "Uniformity of Teachers' Marks versus Variability," John L. Stewart; "Home Economics Courses and the Higher Institutions of Learning," Agnes F. Morgan.

Scientific Monthly, for October; *Garrison, N. Y.: $5.00 per year, 50 cents a copy:* "Oceanography and the Sea-Fisheries," A. W. Herdman; "The Internal Constitution of the Stars," A. S. Eddington; "The Scientific" Study of Alloys," C. T. Heycock; "Where Does Zoology Stand?" J. Stanley Gardiner; "The Map of Europe After the War," John McFarlane; "The Economic Condition of Europe After the Napoleonic War," Dr. J. H. Clapham; "The Strength of Materials in Aeroplane Engineering," C. F. Jenkin; "John Tyndall," Arthur Whitmore Smith; "Governmental Research," Dr. George K. Burgess; "The Mathematician, The Farmer and the Weather," Thomas A. Blair; "Ancient Bacteria and the Beginning of Disease," Roy L. Moodie; "Zoology in the A. E. F.," Dr. Robert T. Hance.

Torreya, for July-August; *Brooklyn Botanic Garden, Brooklyn, N. Y.: $1.00 per year, 30 cents a copy:* "Southern Louisiana from the Car Window," Roland M. Harper; "Value of Nutrient Solutions as Culture Media for Fern Prothallia," E. D. W. Brown; "Two New West Indian Plants," N. L. Britton.

Dietetics for High Schools, by Florence Willard, Washington Irving High School, New York City, and Lucy H. Gillett, Boston. Pages xx+201. 13x19 cm. Cloth, 1920. Macmillan Company, New York.

The crop of books on domestic science has been pretty heavy during the last few years, but none of them have a higher working value than this particular volume. It treats primarily of the kinds of food not for the family alone but for the community. It is the author's belief that the health and welfare of the community depend largely upon the kind of food they consume. The purpose of the book is to teach the best methods and applications of the principles of dietetics to the girls of the high schools. There are twelve chapters. At the end of each chapter is a bibliography of books bearing upon the matter discussed in that chapter. There are many practical problems scattered throughout; valuable tables, too, are presented. A book that every teacher of home economics ought to possess.

C. H. S.

The Elements of Physics, by R. A. Houston, University of Glasgow. Pages viii+221. 14.5 by 22 cm. Cloth. 1920. $1.90. Longmans, Green and Company, New York City.

This book is written primarily as a text book for schools and beginners in physics. It is more specially prepared for those who are fitting themselves to study medicine. The book is systematically prepared. It does not follow the laboratory method of teaching to any extent. There are 202 figures, many of which have been made new for this volume. The discussion of the matter is clear, to the point, and is a book of authority. It deserves, and doubtless will have, a wide circulation. C. H. S.

Introduction to Vocational Education, by David C. Hill, President of the University of Mexico. Pages xvii+483. 14x19½ cm. Cloth. 1920. Macmillan Company.

It is only recently that educators have turned their attention to vocational education. They now realize that in order to secure the very highest efficiency in academic circles as well as those of a vocational nature the student must be thoroughly understood. There is yet a misunderstanding as to the proper approach to best instruct the individual in vocational training. This text has been prepared by a person who is, probably, better qualified to write on this subject than any other in the country. It is a masterpeice, splendidly written, scientifically correct, full of information, covers the ground thoroughly, and put up in such a manner as to make interesting reading for the ordinary layman. There are thriteen chapters. Major paragraphs begin with bold face type. There are, scattered throughout the book, graphs and tables of statistics. At the end of each chapter, there is a summary of the work presented, likewise a very extended bibliography. It is well indexed, mechanically well made, and is a book which all people interested in vocational training should read and study. C. H. S.

South, by Sir Ernest Shackleton, with 88 pictures and diagrams. Pages xxi+374. Cloth. 1920. Macmillans Company, New York City.

One hardly knows just how to begin a comprehensive review of this most interesting and remarkable account of the latest Antarctic expedition. It sets forth to its readers the tremendous energy, persistency, endurance, ingenuity, general all round unselfishness, good fellowship and all other qualifications that go to make up a true man, of the person who originated and engineered this remarkable undertaking.

The Endurance and Aurora were the two vessels selected which should carry the expedition, the fitting out of which was under the direct supervision of the author of this book. One knowing the man understands that there was nothing lacking in the equipment which should have made the expedition a success. It was no fault of the men comprising its crews or the equipment that the results expected to be attained were not reached. It was the combinations of many of Nature's forces and circumstances, absolutely unforeseën and unexpected, that caused the expedition to fail in many of the aspects and results which the commander hoped to attain.

From the human standpoint it surely does increase one's faith in humanity when we read of the remarkable endurance and ingenuity of Shackleton, Wild, and Stenhouse, and of the extraordinary unselfishness of the unfortunate Spencer-Smith.

Shackleton certainly showed his courage when he attempted relief for his followers by taking passage in a small boat only twenty feet long with five of his men from Elephant Island to South Georgia, a distance of 800 miles over one of the most stormy seas of the south, the temperature of the air being, most of the time, below zero.

This book makes interesting reading for the layman and for people interested in the geography of the polar regions. It is a whole mine of information. It is a book that every one interested in this phase of knowledge should possess. C. H. S.

Practical Physics, by Robert A. Millikan and Henry G. Gale, University of Chicago, and Wm. R. Pyle, of Morris High School, New York. Pages x+462. 13.5x19 cm. Cloth. 1920. Ginn & Co., Boston.

This is a revised edition of this well-known and splendid text, previous editions of which have had an extraordinarily wide circulation. Former editions have already been reviewed in this journal. It is not necessary to go into any elaborate review of this text, owing to the fact that previous editions are so well-known. The book has been brought down to date in every respect with the addition of drawings and illustrations of current apparatus. There are 476 half-tones and drawings. A splendid paragraph on three-color printing has been added. There are scattered throughout the book, especially at the end of the various chapters, many practical problems bearing upon the subject matter treated in that chapter. Major paragraphs begin with bold face type, being a leader of thought which is discussed in that paragraph. There is an appendix of eighteen pages of splendidly selected, practical problems. The index consists of eight double-column pages. There is no question but what it will have a splendid circulation. The mechanical part of the book represents perfection in book making. C. H. S.

Animal Husbandry, by John L. Tormey and Rolls C. Lawry, University of Wisconsin. Pages 351. 13.5x19 cm. Cloth. 1920. American Book Company, New York City.

This splendid book which has just come from the press is one of the best in this phase of work. It treats of the art of breeding, feeding, and caring for live stock, as found on the farm, and is based on the fundamental principles underlying caring for farm animals. It discusses the principles and methods of raising suitable foods for stock, and the reasons for crop rotation, in fact, everything bearing upon the raising of the highest type of farm animals. The up-to-date dairyman is fully aware of the fact that he is confronted from time to time with new problems, problems originating outside of his own farm life, problems that have been brought about by the changing conditions of civilization. He must know just exactly what to do with his stock in order to reach the highest efficiency as far as his farm is concerned.

This is a book which should be in the library of every progressive stock man. It is splendidly written, makes interesting reading for the ordinary reader. There are twenty-three chapters and a complete index. It is beautifully illustrated with 118 finely selected half-tones. It should have a wide circulation. C. H. S.

American Red Cross in the Great War, by Henry P. Davison, Chairman of the War Work Council. 302 pages. 13.5x19 cm. Cloth. 1920. Macmillan Co., New York City.

What will one say concerning this most magnificent work of the American Red Cross during the Great Recent War? What would American soldiers have done without it? Too much cannot be said in praise of the noble work done for humanity through this organization. This book treats of the work as a whole. No names are mentioned in the text. Files of the War Work Council have been drawn upon freely for matter contained in this volume. It is a book that every one interested in the Red Cross work should get and read. It is splendidly written, interesting, easy to understand, reads like a novel, and when once one begins reading it, he will have difficulty in stopping until he has finished. It is printed on uncalendared paper, thus avoiding the glare of reflecting light.

C. H S.